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Astronomy®

June 2002

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Are Astronomers Sure They Exist?

Name the Nebulae Contest
Photo Gallery begins on p. 28

Celestron's G-9.25 Scope Reviewed

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*Right-to-left: Meade 8", 10", and 12"
LX200GPS Schmidt-Cassegrain telescopes.
Manufactured under U.S. Patent No.
6,304,376; other patents pending in
the U.S.A. and worldwide.*

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Meade® LX200GPS: the most important advance in Schmidt-Cassegrain technology in ten years is here.

For the visual observer, the astrophotographer, the CCD imager: all the telescope you could possibly have imagined.

For the advanced amateur, new Meade LX200GPS telescopes offer absolutely state-of-the-art optical, mechanical, and electronic performance unmatched by any competing models. Standard-equipment features include:

Precision GPS Alignment: Telescope alignment is accomplished automatically using integrated true-level and North electronic sensors in combination with a 16-channel GPS receiver located in the left-hand fork arm. Magnetic declination compensation is designed into the software and automatically engaged. Just press the *ENTER* button on the Autostar II hand controller and watch as the telescope slews at 8°/second to its first alignment star. *Competing GPS telescopes use a 12-channel receiver (resulting in slower and less reliable position acquisition), do not include any magnetic declination compensation, and can easily result in first-alignment-star errors of up to 20° or more.*

All LX200GPS models include the Zero Image-Shift Microfocuser as standard equipment. The primary mirror lock-knob is located directly above the manual focus knob.

Revolutionary new rear-cell systems designed for the advanced visual observer, astrophotographer and CCD imager — systems that enable new levels of precision in focusing in all applications and in image centering on CCD chips:

Primary Mirror Lock: Flip a knob located just above the manual coarse-focus knob and lock the telescope's primary mirror rigidly in place. Used in conjunction with the Zero Image-Shift Microfocuser *(below)* the primary mirror lock cancels any residual image shift while focusing during visual, photographic, or CCD imaging applications.

Zero Image-Shift Microfocuser: Now you can obtain the most precise image focus possible — truly to a microscopic level — during visual and astrophotographic applications, and, during CCD applications, simultaneously maintain precise image centration on even the smallest CCD chips. Included as standard equipment with all LX200GPS Schmidt-Cassegrain models, the Meade Zero Image-Shift Microfocuser operates at 4 different speeds from extremely slow to fast and is actuated through the Autostar II handbox. Coarse manual focusing is effected through the telescope's manual focus knob.

Autostar II: The new Autostar II control system provided with LX200GPS models includes all of the features that made previous LX200 models the largest-selling serious telescopes in the world. In addition, Autostar II includes an expanded 3.5 Megabyte memory, with a greatly enlarged database of more than 145,000 celestial objects, a database that is immediately accessible on the Autostar II display. A partial listing of the Autostar II database:

Library	No. of Objects
New General Catalog (NGC)	7840
Index Catalog (IC)	5386
Uppsala Galaxy Catalog	12,940
Morphological Catalog of Galaxies	12,939
General Catalog of Variable Stars	28,484
SAO and Hipparcos Star Catalogs	42,277
Draper Star Catalog (HD)	21,127
Yale Bright Star Catalog (BSC5)	6150
Large Bright Quasars Survey (LBQS)	1055
Messier Catalog (M)	110
Caldwell Catalog	109
Named Objects	227
Herschel Catalog	400
Abell Catalog of Galaxy Clusters	2712
Arp Catalog of Irregular Galaxies	645
Major planets from Mercury to Pluto	8

SPECIFICATIONS: 7", 8", 10", and 12" LX200GPS — Each complete telescope includes 8", 10", or 12" f/10 Schmidt-Cassegrain or 7" f/15 Maksutov-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); primary mirror lock; 4-speed zero image-shift microfocuser; heavy-duty fork mount with 4" polar ball bearing, dual-axis 5.75" worm gears, and 7-port multi-function control panel, including two RS-232 serial interface ports; manual and electric slow-motion controls on both axes; Autostar II control system with 3.5-Megabyte flash memory, digital readout display, permanently programmable Smart Drive and 185-speed drive controls on both axes, High-Precision Pointing, and GO TO controller; 145,000-object onboard celestial software library; GPS alignment system with 16-channel GPS receiver, magnetic declination compensation, and true-level and North electronic sensors; 12vDC telescope power supplied from internal battery compartments accepting 8 (user-supplied) C-cells (optional 25 ft. cords available for powering from auto cigarette lighter plug or from 115vAC); 8 x 50mm viewfinder; 1.25" diagonal prism (7", 8", 10") or 2" diagonal mirror with 1.25" adapter (12"); Series 4000 Super Plössl 26mm eyepiece; standard field tripod (7", 8", 10") or giant field tripod (12"); operating instructions.

MEADE LX200GPS SCHMIDT-CASSEGRAIN TELESCOPES

8" LX200GPS	**$2495**
10" LX200GPS	**2995**
12" LX200GPS	**3995**
7" LX200GPS Maksutov-Cassegrain	**2995**

Ultra-High Transmission Coatings (UHTC) group *(see ad in this issue)*: 8" LX200GPS – $175; 10" LX200GPS – $235; 12" LX200GPS – $295; 7" LX200GPS – $150.

Packing & shipping charges in the 48 states: 8" – $105; 10" – $145; 12" – $215; 7" – $125. Prices shown are suggested U.S. national mail-order retail prices.

A COMPARISON OF GPS SCHMIDT-CASSEGRAIN TELESCOPES

	Meade LX200GPS	Competing 11" GPS*
GPS Receiver	16-channel	12-channel
Magnetic declination compensation	yes	no
True-level electronic sensor	yes	no
Primary mirror lock	yes	no
Zero image-shift microfocuser	yes	no
Maximum slew speed	8°/second	3°/second
Drive speeds, each axis	185 speeds, from .01x sidereal to 8°/sec.	9 speeds, from 0.5x sidereal to 3°/sec.
Tracking rates	sidereal, lunar, or custom-selected from 2000 rates	sidereal, lunar, or solar
Memory	3.5-Meg flash	1.0-Meg flash
GO TO pointing precision	2-arcmins	unstated
High-precision pointing mode	yes; permits GO TO pointing precision within 1-arcmin	no
Permanent Periodic Error Correction	yes, both axes	one axis only; second axis unprogrammable
Object database	147,541 objects	"40,000+"
Encoder resolution	0.14 arcsecs	0.26 arcsecs
Internal battery compartments for battery powering	yes; batteries located internal to fork arms	no
RS-232 software download	yes; object libraries and software downloads available	not currently available on factory website**
Tracking calibration	not required	recommended after changes in telescope position or load

*Based on sample and instruction manual received in 7/01. ** As of 2/5/02.

AUTHORIZED MAIL-ORDER DEALERS

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

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Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

CANADA

EFSTONSCIENCE, Toronto, Ontario, Canada
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario, Canada
Orders & Information: 416-783-4140.

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COVER PHOTO: Jason Ware

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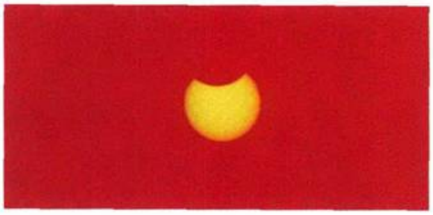

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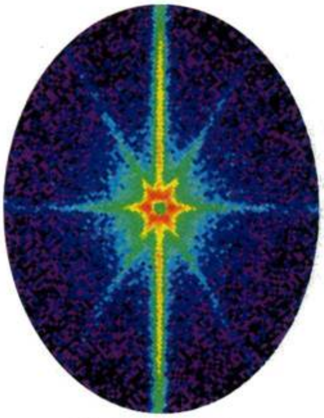
NASA/STScI

DEPARTMENTS



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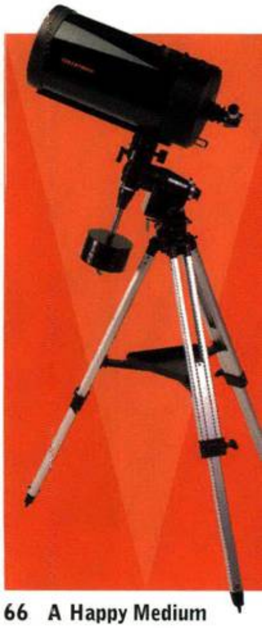

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BEHIND THE SCENES

BY BONNIE BILYEU GORDON

Naming the Nebulae

For several years we have joked about those sky phenomena that go by no other calling than a number. Whether NGCs, ICs, or Messiers, these objects, especially nebulae, rank among the most beautiful in the night sky. As such, many cry out for popular tags. At *Astronomy* we have decided to launch a campaign that would give names to some of our favorite, most-deserving sky objects, and we invite you to join us.

Though many of the nebulae — such as the Horsehead, the Lagoon, and the Trifid — have been called by their popular names so often that the names seem official, not one of those names is recognized by the International Astronomical Union. Still worse is the lack of any moniker for many in the bunch.

Ken Blankenship and Dennis Batis

Help name and rename a few of the most beautiful nebulae, such as NGC 6559, above. Go to page 28 or Astronomy.com.

We've taken it upon ourselves to have a little fun with these nameless nebulae and give away a few prizes to our readers for their efforts to help us. We have picked several photos of fine night targets, most of which carry no popular name at all. A few of our choices have popular names that don't completely please us, and those you are welcome to rename. You will find an easy way to enter the contest online at Astronomy.com, but of course you may send an entry by post as well. But first go to page 28 and check out our beautiful images.

We would also like to share a bit of news about one of our contributors, Dave Tannebaum, the author of "Space Law" in the February 2002 issue. He won a recent AAAS Journalism on-line award for "Buried Treasure," which appeared on *The Why Files*. He also won the National Association of Science Writers' Science in Society Award for Web Journalism for "Energy Crisis III?" which also apeared on *The Why Files*. Please join us in congratulating him.

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MEADE

LXD55

6" 8" 10"

SCHMIDT-NEWTONIANS WITH AUTOSTAR®

Now you can buy a Meade Schmidt-Newtonian telescope with Autostar dual-axis GO TO drive system for as little as $599, *complete!*

Schmidt-Newtonian Optical Systems: Manufactured entirely at the Meade Irvine facility, LXD55 diffraction-limited Schmidt-Newtonian optics yield pinpoint stellar images over extremely wide fields, with *one-half* the coma of paraboloids of the same focal ratios, for brilliant, rich-field imaging of nebulae, galaxies, and star clusters. High-power lunar and planetary images reveal subtle detail often lost in telescopes of lesser optical resolution.

LXD55 Equatorial Mount: Designed by Meade engineers and manufactured of machined aluminum for high-performance photo-visual observing, the new Meade LXD55 mounting moves effortlessly across the skies in either tracking or automatic GO TO modes. Included is an illuminated polar viewfinder for quick, precise polar alignment.

Autostar Dual-Axis Electronic Control System: A revelation of advanced electronic and software design, the exclusive patent-pending Meade Autostar system, included as standard equipment with every LXD55 telescope, permits an amazing range of capabilities never before offered on telescopes in this price and aperture class: *Automatic GO TO capability* at 4.5°/second on both axes simultaneously, to 30,223 database objects; *nine selectable slew and slow-motion speeds from* 1x sidereal to 4.5°/sec.; *automatic sidereal-rate tracking in R.A.* keeps objects precisely centered in the field.

Battery Pack (12vDC): Included with each LXD55 telescope; rests on the telescope's accessory shelf and plugs into the control panel. The battery pack accepts eight (user-supplied) D-cell batteries, which power the telescope for more than 40 hours.

SPECIFICATIONS: Models SN-6, SN-8, and SN-10 Schmidt-Newtonian Telescopes — Each complete telescope includes 6" f/5, 8" f/4, or 10" f/4 Schmidt-Newtonian optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally); quick-release cradle ring assembly with locks; 6 x 30mm achromatic viewfinder; metal rack-and-pinion focuser with eyepiece holders for both 1.25" and 2" eyepieces; Series 4000 Super Plössl 26mm eyepiece. LXD55 German-type equatorial mount with worm gear drives and electric slow-motion controls on both axes; micrometric controls for azimuth and elevation adjustments; illuminated polar alignment finder with reticle; variable-height field tripod with accessory shelf. Autostar dual-axis control system with digital readout display; 9-speed drive controls; 30,223-object celestial software library and automatic GO TO object-locating. Battery pack accepting eight (user-supplied) D-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); operating instructions.

MEADE LXD55-SERIES SCHMIDT-NEWTONIAN TELESCOPES

Shipped complete per specifications above:

6" Model SN-6 Schmidt-Newtonian	**$599**
8" Model SN-8 Schmidt-Newtonian	**729**
10" Model SN-10 Schmidt-Newtonian	**879**

Ultra-High Transmission Coatings (UHTC) group *(see ad in this issue)*: 6" Model SN-6 – $85; 8" Model SN-8 – $125; 10" Model SN-10 – $150.

Packing & shipping charges in the 48 states: 6" – $75; 8" – $85; 10" – $95. Prices shown are suggested U.S. national mail-order retail prices.

MEADE
LXD55
Model SN-6
6" f/5
Model SN-8
8" f/4
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10" f/4

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LX90

MEADE

8" LX90

THE TELESCOPE OF A LIFETIME

Worm gears of 4.9"-diameter on both telescope axes for smooth sidereal-rate tracking of celestial objects as well as precise guiding corrections during long-exposure imaging.

Die-cast-aluminum *double-tine* fork mount that rigidly supports the optical tube in all sky orientations.

The LX90 is powered for 60 hours by 8 (user-supplied) C-cell batteries. Alternately, the telescope may be powered from an automobile cigarette lighter plug or from a standard 115vAC home outlet, using optionally available power cords.

Rigid chromed-steel variable-height field tripod — *the same tripod provided with Meade LX200GPS models.*

The Meade 8" LX90, with diffraction-limited Meade optics in an Autostar computer-controlled telescope system, includes capabilities not available on other brands of 8" Schmidt-Cassegrains costing hundreds of dollars more. Incorporating the optical system of the 8" LX200GPS, and with 5 arc-minute pointing precision in the GO TO mode, the LX90 is an instrument fully qualified for long-exposure CCD imaging and astrophotography as well as for other advanced photo-visual applications.

Autostar™ Computer Controller: The LX90's *standard-equipment* Autostar controller permits an incredible array of telescope features:

- *Automatic GO TO capability* at 6.5°/sec on both axes, simultaneously, to 30,223 database objects, including:
  - 13,235 deep-sky objects — the complete Messier, Caldwell, IC, and NGC catalogs; 16,888 stars; the 8 major planets; the Moon; 26 asteroids; 15 comets; 50 Earth satellites; plus 200 user-defined memory locations.
- *Automatic GO TO capability* to *any* object of known R.A. and Declination. Plus hundreds of special event menus, guided tours, utility functions, and telescope status options.
- *Nine selectable slew speeds:* 6.5°/sec, 3°/sec, and 1.5°/sec, as well as 128x, 64x, 16x, 8x, 2x, and 1x sidereal.
- *Control of the telescope* through your personal computer. (Requires optional #505 Connector Cable Set.)
- *Fast alignment of the telescope* using any of three alignment functions, including the Meade-proprietary Easy Align.
- *Autostar is fully upgradeable over the Internet:* add the positions of new comets, update the positions of Earth satellites, even add new software.

8" LX90
Schmidt-Cassegrain
$1695

The Meade 8" LX90 is manufactured under U.S. Patent No. 6,304,376; other patents pending in the U.S.A. and worldwide.

SPECIFICATIONS: 8" LX90 — Each complete telescope includes 8" f/10 Schmidt-Cassegrain optical tube assembly with MgF_2 coatings on the correcting lens and standard aluminum coatings on the primary and secondary mirrors (Ultra-High Transmission Coatings available optionally; see below); double-tine fork mount with dual-axis 4.9" worm gears and control panel; electric slow-motion controls on both axes; Autostar hand controller with digital readout display, 9-speed drive controls on both axes, and GO TO controller; 30,223-object onboard celestial software library; internal battery port accepts 8 (user-supplied) C-cells (optional 25 ft. cords permit powering from either 12vDC auto cigarette lighter plug or from 115vAC home outlet); 8 x 50mm viewfinder; 1.25" diagonal prism; Series 4000 Super Plössl 26mm eyepiece; standard field tripod; operating instructions. **$1695. Ultra-High Transmission Coatings group** *(see ad in this issue)*: **add $175.** Packing & shipping in the 48 states: $95.

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Increase the image brightness and resolution of your Meade® telescope by 20% with the Meade® Ultra-High Transmission Coatings™ (UHTC) group.

Now you can increase the image brightness and resolution of your Meade ETX Maksutov-Cassegrain; LX10, LX90, or LX200GPS Schmidt-Cassegrain; or 6", 8", or 10" LXD55 Schmidt-Newtonian **by 20%** simply by specifying the Meade Ultra-High Transmission Coatings (UHTC) group with your telescope order.

Meade Standard Coatings: Meade standard-equipment coatings include mirror surfaces of highly purified aluminum, vacuum-deposited at high temperature and overcoated with silicon monoxide (SiO), and correcting lenses coated on both sides for high light transmission with magnesium fluoride (MgF_2). *Meade standard mirror and lens coatings equal or exceed the reflectivity and transmission, respectively, of virtually any optical coatings currently offered in the commercial telescope industry.*

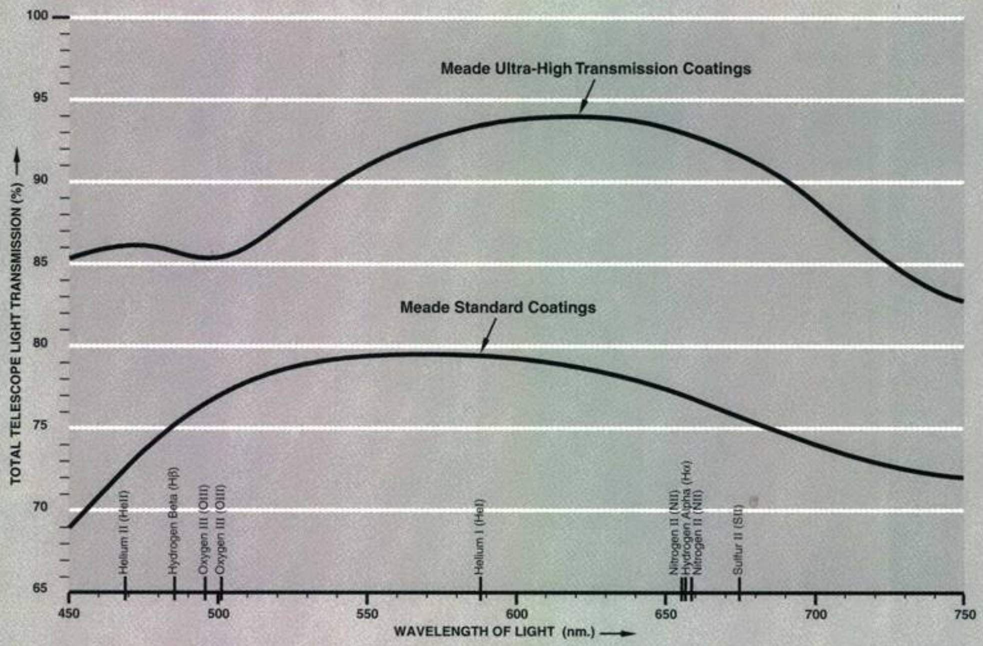
The Meade UHTC Group: Technologies recently developed at the Meade Irvine coatings facility, however, including installation of some of the largest and most advanced vacuum coating instrumentation currently available, have permitted the vacuum-deposition of a series of exotic optical coatings precisely tuned to optimize the visual, photographic, and CCD imaging performance of Meade telescopes.

In Meade mirror-lens telescopes, before incoming light is brought to a focus, it passes through, or is reflected by, four optical surfaces: the front surface of the correcting lens, the rear surface of the correcting lens, the primary mirror, and the secondary mirror. Each of these four surfaces results in some loss of light, with the level of loss being dependent on the chemistry of each surface's optical coatings and on the wavelength of light.

Mirror Coatings: Meade ETX, Schmidt-Cassegrain, and Schmidt-Newtonian telescopes equipped with the Ultra-High Transmission Coatings group include primary and secondary mirrors coated with aluminum enhanced with a complex stack of multi-layer coatings of titanium dioxide (TiO_2) and silicon dioxide (SiO_2), and with the thickness of each coating layer precisely controlled to within ±1% of optimal thickness. The result is a dramatic increase in mirror reflectivity across the entire visible spectrum; at the important hydrogen-alpha wavelength of 656nm. — the predominant wavelength of emission nebulae — reflectivity is increased from 89% to over 97%.

Control panel of a Meade UHTC electron-beam vacuum coater.

BOC
TSC-1460
Temescal



Total telescope light transmission by wavelength of light. These graphs show the total amount of light transmitted to the telescope focus by the four optical surfaces (primary mirror, secondary mirror, and two lens surfaces) of Meade ETX, Schmidt-Cassegrain, and Schmidt-Newtonian telescopes. The wavelengths of the brightest nebular emission lines are indicated. Meade standard coatings equal or exceed the total light transmission of virtually all other optical coatings currently offered in the commercial telescope industry; notwithstanding this fact, Meade UHTC coatings enable a dramatic increase in lunar, planetary, and deep-space image brightness and resolution. Note that the graphs presented here are spectrophotometric results of actual Meade mirrors and correcting lenses, not theoretical abstractions.

Correcting Lens Coatings: Meade telescopes ordered with the UHTC group include, in addition, an exotic and tightly-controlled series of coatings on both sides of the correcting lens or correcting plate, coatings which include multiple layers of aluminum oxide (Al_2O_3), titanium dioxide (TiO_2), and magnesium fluoride (MgF_2). Per-surface light transmission of the correcting lens is thereby increased at the yellow wavelength of 580nm., for example, to 99.8%, versus a per-surface transmission of 98.7% for the standard coating.

The importance of the UHTC group becomes apparent when comparing *total* telescope light transmission caused by the compounding effect of the four optical surfaces. With each optical surface contributing significantly to total telescope light transmission, the effect of all four surfaces *combined* is indeed dramatic, as demonstrated by the graphs above. At the H-alpha wavelength of 656nm., total transmission increases from 77% to 93%, an increase of 93/77, or 21%; at the oxygen-III wavelengths of 496nm. and 501nm. — important emission lines in diffuse and planetary nebulae — total transmission increases from 76% to 85%, an increase of 85/76, or 12%; at the helium wavelengths of 588nm. and 469nm. — strong emission lines in hot planetary nebulae — total telescope transmission increases by 18% and 19%, respectively. ***Averaged over the entire visible spectrum (450nm. to 700nm.), total light transmission to the telescope focus increases by about 20%.***

Observing with the UHTC: Meade telescopes equipped with UHTC present dramatically enhanced detail on all celestial objects — from emission and planetary nebulae such as M8, M20, and M57; to star clusters and galaxies such as M3, M13, and M101; to the Moon and planets. The overall effect of the UHTC is, as it relates to image brightness and resolution, to increase the telescope's effective aperture. **Image brightness and resolution (*i.e.*, the ability to image fine detail) of the Meade 10" LX200GPS are, for example, effectively increased by about one full inch of aperture.**

Pricing: *The Meade Ultra-High Transmission Coatings group, if desired, must be specified at the time of telescope purchase; the UHTC can not be retrofitted.* The UHTC is available for any of these Meade telescopes:

ETX-90EC–$50; ETX-105EC–$75; ETX-125EC–$95

8" LX10, 8" LX90, or 8" LX200GPS–$175;
10" LX200GPS–$235; 12" LX200GPS–$295

LXD55 Schmidt-Newtonians: 6" Model SN-6–$85; 8" Model SN-8–$125; 10" Model SN-10–$150

ADVANCED PRODUCTS DIVISION

Meade Instruments Corporation

The largest-selling telescopes in the world. ■ *A NASDAQ® company.*
6001 Oak Canyon, Irvine, California 92618 ■ (949) 451-1450
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MEADE®

RESEARCH-GRADE ACCESSORIES

Series 4000™ Super Plössls
52° field; multi-coated

Meade 4-element Super Plössls, updated and redesigned to utilize the latest in optical glass-types, are the finest general-purpose eyepieces available. For observing hairline lunar and planetary detail, splitting close doubles, or for deep-space; guaranteed to deliver more contrast and image sharpness than any other brand. Rubber eyeguards fold down for eyeglass wearers–a feature not available on competing brands. Multi-coated. All focal lengths through 32mm are parfocal.

Super Plössls (SP; 4-elements; 1.25"; 52°):

6.4, 9.7, 12.4, 15, 20, 26mm	each: **$79.95** (4.54)
32mm (52°); **40mm** (44°)	each: **99.95** (5.26)
56mm (52°; 2")	**199.95** (7.02)

Series 4000™
2x Apochromatic Barlow Lens

#140: The most advanced Barlow lens available for commercial telescopes, the Meade #140 includes 3-element, multi-coated, air-spaced optics. Doubles the power of any eyepiece with which it is used and yields images absolutely unmatched in resolution, contrast and color correction. The #140 optically complements any telescope — refractor, reflector, or Schmidt-Cassegrain. Accepts 1.25" eyepieces. Mechanical components are of machined aluminum and brass. Lens diameter is 28mm; clear aperture 26mm.

$79.95 (5.26)

Series 4000™ Super Wide Angle
67° field; multi-coated

For exquisite wide-angle images at low-to-medium powers, with pinpoint edge-of-field resolution. Ideal for star fields, galaxies, and other deep-space phenomena. SWA 13.8mm, 18mm, and 24.5mm are superb complements to the #140 Barlow, above.

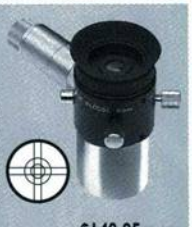
Super Wide Angle (SWA: 6-elements; 1.25"; 67°)–**13.8mm: $139.95** (4.54); **18mm: 149.95** (4.54); **24.5mm: 179.95** (5.26); **32mm** (2"): **239.95** (7.02); **40mm** (2"): **299.95** (7.02)

Series 4000™ Ultra Wide Angle
84° field; multi-coated

The ultimate eyepieces; extreme image sharpness over an amazing 84° field. A perfect optical match with Schmidt-Cassegrains and fast Newtonians.

Ultra Wide Angle (UWA; 8-elements; 1.25"; 84°)– **4.7mm: $169.95** (5.26); **6.7mm: 199.95** (5.26); **8.8mm** (1.25"/2"): **239.95** (7.02); **14mm** (1.25"/2"): **299.95** (7.02)

World's Most Advanced Illuminated Reticle Eyepiece



Series 4000 Plössl 9mm, with rubber eyecup and micrometric X-Y positioning of the reticle within the field. Greatly facilitates locking on the guide star. Sharp high-power imaging, excellent eye relief. Wireless red LED illuminator with adjustable brightness control. Multi-coated optics. **Internal batteries included.** Bullseye reticle. 1.25".

$149.95 (6.14)

Series 4000 Plössl 9mm—Same as above but with 6 ft. cord and plug for Meade LX3, LX5, LX6, LX100, LX200, and APO power panels, in place of wireless illuminator.

$129.95 (5.26)

Series 3000™ Plössls
50° field; multi-coated

Meade Series 3000 Plössls yield the finest image corrections obtainable from the classical 4-element Plössl design. Focal lengths from 5mm through 25mm are parfocal, so that, at most, only slight refocusing of the image is necessary from eyepiece to eyepiece. Unlike competing moderately-priced Plössls, Meade Series 3000's are **multi-coated** for maximum light transmission and image contrast. Chrome-plated brass barrels are threaded for standard filters. All eyepieces are fitted with fold-down rubber eyecups for comfortable observing. The PL40mm (*far right in photo*), an excellent complement to any ocular set, produces spectacular low-power, wide fields, ideal for scanning the Milky Way. Manufactured exclusively to Meade optical designs, Series 3000 Plössls yield fine, high-resolution results on reflectors, refractors, and Schmidt-Cassegrains of any focal ratio.

Series 3000 Plössls (4-elements; 1.25"; 50°)

5, 6.7, 9.5, 16, 25mm each: **$49.95** (3.86); **40mm $79.95** (3.86)

Series 4000™
f/6.3 Focal Reducer/ Field Flattener

Manufactured to exclusive Meade optical designs; threads on to any Meade or Celestron Schmidt-Cassegrain rear cell and converts f/10 scopes to f/6.3 (or f/6.3 SCT's to f/4), while significantly flattening the field. Use with SCT visual or photo accessories. Actual visual field is increased by 56%, for fine wide-field views of star fields and nebulae. In astrophotography, reduces exposure times by about 50%, while producing an actual field diameter of 1.5" at the film plane. A tremendous aid with CCD imagers in reducing image size for locating and centering images on CCD chips. 4-element optics; multi-coated; 41mm clear aperture.

$129.95 (5.26)

Series 4000 Photo-Visual Color Filters (1.25")–Premium filters, made of purest crown optical glass, dyed in the mass. For increased contrast and resolution on the Moon and planets. Thread into the barrels of virtually all 1.25" eyepieces sold today. Fully coated.

#8 Lt. Yellow; #11 Yellow Green; #12 Yellow; #21 Orange; #23A Lt. Red; #25A Red; #38A Dark Blue; #47 Violet; #56 Lt. Green; #58 Green; #80A Blue; #82A Lt. Blue

each **$14.95** (2.73)

Set #1–4 filters: #12, #23A, #58, #80A	**49.95** (4.54)
Set #2–4 filters: #11, #25A, #47, #82A	**49.95** (4.54)
Set #3–4 filters: #8, #21, #38A, #56	**49.95** (4.54)

Series 4000 Moon Filter (#ND96): Reduces glare and irradiation during lunar observing. 13% uniform light transmission across the visual spectrum. Threads into 1.25" barrels.

$16.95 (2.73)

#911B
#911N
#908B
#908N

Series 4000 Nebular Filters—Premium multi-layer interference filters, the finest obtainable. Use broadband ("B") filters to block most forms of light pollution; use narrowband ("N") filters in heavily light-polluted areas or for extremely high-contrast observing of faint nebulae.

#908B–Threads into 1.25" eyepieces, 26mm dia.	**79.95** (4.54)
#911B–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**99.95** (5.26)
#908N–Threads into 1.25" eyepieces, 26mm dia.	**89.95** (4.54)
#911N–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**119.95** (5.26)

Series 4000 Oxygen-III Filters
Observe diffuse emission and planetary nebulae as you never thought possible! Exclusive Meade 60-layer interference coating technology isolates the 496nm and 501nm O-III lines to tremendously enhance observable nebular structural detail in all telescopes.

#908X–Threads into 1.25" eyepieces. 26mm dia.	**99.95** (4.54)
#911X–Threads on to rear cell of Schmidt-Cassegrain telescopes. 36mm dia.	**149.95** (5.26)

2x Telenegative Barlow (1.25")

#122: Doubles eyepiece power with sharp, high-resolution, high-contrast imaging on telescopes of all types. 27mm dia. (26mm clear aperture). Excellent corrections for chromatic and spherical aberrations at all photo-visual wavelengths. Multi-coated. 1.25"

$47.95 (4.54)

#905 Variable Polarizer (1.25")

For glare reduction in observing the Moon. Includes two Polarizer filters mounted in a machined cell and permits continuously variable light transmission from 5% to 25%, to compensate for varying lunar surface brightness according to the Moon's phase and the aperture of the telescope. Accepts 1.25" eyepieces.

$49.95 (5.26)

2x Short-Focus Barlow (1.25")

#126: Only 2.5" long, the #126 works well with any telescope accepting 1.25" eyepieces, even those with limited focus range. Maintains the high image quality of the #122, above. Insert the #126 into star diagonal for 2x or insert star diagonal into #126 for 3x. 26mm clear aperture. Multi-coated.

$47.95 (4.54)

2x-3x Variable Barlow (1.25")

#127: Precision internal sliding lens assembly permits continuously variable power settings between 2x and 3x. Engraved scale indicates power in use. Yields bright, sharp, high-contrast images on telescopes of all types. Multi-coated; 1.25".

$59.95 (4.54)

2" Diagonal Mirror

#929: Permits use of wide-field 2" oculars. Threads on to rear cell of Meade and Celestron SCT's. Includes UHTC-coated (95%+ reflectivity) precision optical flat made at the Meade factory; with 1.25" eyepiece adapter. **#930:** Same as #929 but with 2" barrel to fit into focusers with 2" eyepiece-holders.

#929 or **#930,** each: **$99.95** (6.85)

45° Erecting Prisms

Fully coated roof prisms to invert the astronomical image in Schmidt-Cassegrains or refractors during terrestrial observations, while presenting a convenient 45° observing angle. Specify **#927** (.965"), **#928** (1.25"), or **#931** (fits .965" focuser, accepts 1.25" eyepieces).

$42.95 (3.86)

Electric Focusers for SCT's

For extremely smooth microfocusing of the image. Does not affect use of the manual coarse-focus knob.

#1206 Electric Focuser: Plugs into control panel of Meade 8", 10", 12" LX200 models and operates from LX200 hand controller. (Not for LX200GPS models.)

$149.95 (7.48)

#1205 Electric Focuser: For **all** other Meade 8", 10", 12" SCT models; includes separate hand controller; accepts one self-contained (user-supplied) 9v. battery.

$169.95 (7.88)

#777 Off-Axis Guider for SCT's

Internal prism diverts light for monitoring telescopic image during long-exposure astrophotography. Threads to any Meade or Celestron rear cell. Use with illuminated reticle eyepiece and T-Mount for your 35mm camera.

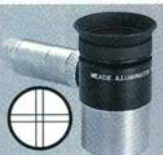
$79.95 (6.85)

Vibration Isolation Pads

Designed by Meade engineers, these isolation pads reduce typical telescope-tripod vibration damping times to less than one second. A tremendous aid for both visual and photographic astronomy. Place one pad under each tripod leg. #895 Vibration Isolation Pads, per set of three:

$49.95 (6.85)

MA12mm Illuminated Reticle Eyepiece



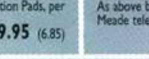
Excellent 3-element optical system, long eye relief, fully coated, with double crossline reticle; rubber eyecup. Wireless red LED illuminator and variable brightness control. 1.25". **Batteries included.**

$99.95 (3.45)

As above but with 6 ft. cord and plug for Meade telescopes with power panels, in place of wireless illuminator.

$79.95 (5.26)

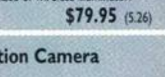
Camera Adapters



Professional-quality adapters for rigid coupling of telescope-to-camera. Use for either Eyepiece-Projection or Prime Focus. Precision-machined of aluminum and brass, threaded for filters. Use with T-mount, available separately.

.965": **$27.95**; 1.25": **$29.95** (3.86)

Variable-Projection Camera Adapter (1.25")



Machined sliding cell allows variable projection power in eyepiece-projection photography; permits precise selection of correct photo power in lunar and planetary photography; threaded for filters. Use with T-mount for your camera.

$39.95 (3.86)

Variable Tele-Extender

For eyepiece-projection photography with any Meade or Celestron SCT. Threads on to eyepiece-holder. Sliding cell with lock permits wide range of projection magnifications with the same eyepiece. Use with T-mount for your camera.

$39.95 (3.86)

T-Adapters for SCT's

Rigidly couples camera to telescope for prime focus photography with any Meade or Celestron Schmidt-Cassegrain. Use with T-Mount for your 35mm camera.

$26.95 (3.86)

CCD-Photo-Visual Flip-Mirror Systems

An essential accessory for imaging with any brand of CCD imager or for astrophotography with a 35mm camera. Flip mirror "down" to center the image while viewing with an eyepiece at 90°; flip mirror "up" to pass light on to CCD chip or 35mm camara film plane. Each unit includes: precision optical-flat Pyrex® mirror; 2-axis mirror-adjustment screws and locks for precise image centering; extra-fine helicoid focusing of the eyepiece; extension tubes for attaching either 35mm camera (using T-Mount) or CCD imager (using either T-threads or 1.25" barrel). Threads to rear cells of all Schmidt-Cassegrain telescopes; may remain on telescope and used in place of diagonal prism for visual observing as well.

"Over the past 10 years I have used all manner of flip-mirrors. The Meade Flip-Mirror Systems are absolutely the best—rock solid, high-precision, beautifully manufactured; they virtually eliminate all flexture between the CCD and telescope." — Jack Newton

#644 Flip-Mirror System: Accepts any 1.25" eyepiece. Mirror clear aperture: 22mm. Use with CCD's up to Pictor 416XTE, ST-7, or AP1, or smaller; or visual observing with 1.25" eyepieces.
$149.95 (7.02)

#647 Flip-Mirror System: Accepts either 1.25" or 2" eyepieces. Mirror clear aperture: 40mm. Recommended for full-field 35mm astrophotography or with CCD's of any size, including all Meade Pictor Series through 1616XTE, or ST-4 through ST-10; or AP2, AP7; or for visual applications with 1.25" or 2" eyepieces.
249.95 (8.49)

#157 1.25" Adapter: Permits use of either Flip-Mirror on telescopes with 1.25" eyepiece-holders. (Requires approx. 2" additional focus travel with #644, 3" with #647.)
15.00 (3.86)

#644

#647

#1209 Zero Image-Shift Microfocuser

Identical to the Microfocuser supplied with Meade LX200GPS telescopes, but provided with a separate hand-box for use with all other Meade SCT models (e.g. LX10, LX50, LX90, LX200) or for Schmidt-Cassegrains of other brands. Threads directly to the telescope's rear cell. Permits extremely precise focusing of the image during visual or photographic applications; during CCD applications maintains precise image centration on even the smallest CCD chips. Operates at four speeds, from extremely slow to fast; accepts both 2" and 1.25" eyepiece barrels. Requires 8 x AAA (user-supplied) batteries.

$249.95 (9.85)

Epoch 2000® Sky Software

The most powerful astronomical software ever made available can now be yours for only $99!

Epoch 2000sk *(upper display at left)*: Use the most advanced, most precise full-color sky software ever created, to zoom-in on telescopic fields **smaller than one arc second!** Dynamically reads out the R.A. and Dec. of the cursor position anywhere in the field **and updates R.A. and Dec. instantaneously as the cursor is moved about the field.** Meade LX200 owners can use Epoch 2000sk for remote auto-centering of objects in the telescopic field **to a precision of 30 arc seconds,** routinely! Print professional-quality star charts in either black-and-white or color, at any zoom setting or sky scale between 180° and one arc second, with your own customized borders, headers, footers, margins, fonts, colors, and grids.

Epoch 2000ip Image Processing Software: Enhance and analyze your CCD images with the same sophisticated techniques used by professional astronomers to uncover hidden structure in a spiral galaxy or obscure detail on the surface of a planet.

EPOCH 2000sk Sky Software: 19 million objects, including the complete Hubble Guide Star Catalog; supplied on CD-ROM for Windows 95, 98, 2000, NT, and XP **$99**

LX200 Interface Cable: for Meade LX200/LX200GPS operation by Epoch 2000sk. **25**

EPOCH 2000ip Image Processing Software: On CD-ROM for Windows 95, 98, 2000, NT, and XP **99**

Series 4000™ f/3.3 CCD Focal Reducer/Field Flattener

Revolutionary 3-element Meade design permits ultrafast CCD imaging with **increased** edge-of-field resolution and color correction! Reduces CCD exposure times by up to 80%. Threads on to the rear cell of any Meade or Celestron Schmidt-Cassegrain. Converts f/10 Schmidt-Cassegrain telescopes to **f/3.3** and f/6.3 SCT's to **f/2.** Variable T-Adapter (included) allows range of f/ratios between f/3 and f/5 on f/10 SCT's and between f/1.9 and f/3.2 on f/6.3 SCT's. Use with CCD imagers of any brand and chip dimensions. Not for visual or photographic applications. Multi-coated; 41mm clear aperture.

$149.95 (5.26)

Plössl 25mm Illuminated Reticle CCD Framing Ocular

Displays rectangular frames of all popular CCD chip sizes, including all Meade Pictor models; ST-4 through ST-8; AP1, AP2; and others. Shows precisely the image size and orientation that appear on CCD chip. Insert directly into telescope eyepiece-holder, or use with Flip-Mirror *(above).* Includes 4-element coated Plössl optics; lockable spacer ring to fix focus position; rubber eyecup; variable LED illumination control; batteries. 1.25".

$129.95 (4.54)

#825 8 x 25mm Right-Angle Viewfinder for ETX-90

Permits comfortable right-angle viewing. Replaces standard-equipment finder on 90mm ETX models, using the same bracket. Wide-angle, achromatic, coated optics; actual field 7.5°. Precise helicoid focusing.

$49.95 (4.26)

#64 T-Adapter for ETX®

Threads to photo port of all ETX-90, ETX-105, and ETX-125 models. Rigidly couples any 35mm camera with removable lens to the telescope for lunar, planetary, or terrestrial photography. Includes extension tube for longer effective focal length, if desired. Use with T-Mount for your 35mm camera.

$34.95 (3.86)

#932 45° Erecting Prism for ETX®

For terrestrial observing with any ETX-90, ETX-105, or ETX-125 model. Yields correctly oriented image and convenient 45° observing angle. Threads to ETX rear cell. Accepts any 1.25" eyepieces. Coated roof prism optics.

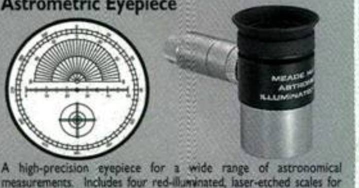
$49.95 (3.86)

Dew Shields for ETX®

Threads into the front-lens cell and effectively inhibits the formation of dew on the lens surface.

#670 for ETX-60/70	19.95
#673 for ETX-90	24.95
#675 for ETX-105	27.95
#678 for ETX-125	29.95

MA12mm Illuminated Reticle Astrometric Eyepiece



A high-precision eyepiece for a wide range of astronomical measurements. Includes four red-illuminated, laser-etched scales for measuring double star angular separations, position angles, planetary diameters, and lunar crater diameters; and for long-exposure photo-guiding. Modified Achromatic 3-element coated optics; diopter adjustment; rubber eyecup; variable LED illumination control; batteries. 1.25".

$119.95 (4.26)

Series 4000™ 8mm – 24mm Zoom Eyepiece

The finest zoom eyepiece available. High-resolution 7-element multi-coated optics, with 55° field at 8mm. Graduated scale in 1mm units indicates exact focal length in use. High-eyepoint yields comfortable observing even with eyeglasses. Internal zoom lenses move on the smoothest, most precisely-machined tracks yet developed for zoom optics. Performance is fully consistent with the finest fixed-focal length eyepieces. Threaded for filters; rubber eyecup; 1.25".

$219.95 (6.38)

ETX® Hard Carrying Cases

For secure storage or travel with your ETX. Thick-wall construction and die-cut foam lining. Accepts telescope, optional eyepieces, erecting prism, table tripod, hand controller, etc. Includes steel latches & key.

#774 Case for ETX-90 models:
99.95 (8.58)

#776 Case for ETX-105EC:
99.95 (8.58)

#775 for ETX-125EC:
149.95 (13.38)

ETX® Carry Bag

Soft-padded Cordura-type carry bag with shoulder strap; permits storage of any 90mm ETX model, plus table tripod legs, eyepieces, other accessories.

$36.95 (5.26)

Pictor 216XT CCD Autoguider/Imager

The most advanced Autoguider/Imager in its price class. For many, all the CCD imager required for a wide range of lunar, planetary, or deep-space applications. Includes the same "point-and-shoot" simplicity of larger Pictor models. Produces smooth, natural 16-bit images of all celestial subjects. Also a precision autoguider during astrophotgraphy.

$695. (12.00)

ETX® Deluxe Field Tripod

#884: Constructed of strong, lightweight steel; designed specifically for ETX-90, ETX-105, and ETX-125 Astro Telescopes. Tripod height adjusts from 25" to 43", for seated or standing observations. Graduated scale for elevation angle from 20° to 90° permits precise polar alignment of the telescope for astronomical applications. Tripod tilts and locks at 90° for terrestrial applications or for altazimuth use with Autostar. Telescope attaches to tripod in seconds with 2 thumbscrews. **Includes custom-fitted carry bag *(shown)* with pocket for accessories.**

$199.95 (10.00)

Advanced Field Tripod for ETX-125

#887: Yields rock-solid stability for sensitive applications of the ETX-125, even at high magnifications. **Includes fixed-height tripod convenient for standing observations, equatorial wedge with alignment controls in azimuth and latitude angle, and #889 Tripod Adapter for ETX-125.** Permits either altazimuth or equatorial orientation of the telescope for astronomical or terrestrial observing. Tripod legs are 2"-diameter chromed steel. For field use the tripod collapses for easy transport.

$349.95 (14.00)

#889 Adapter: Available separately, permits attachment of ETX-125 to any Meade LX10 or LX200 Field Tripod or wedge. **$69.95** (7.70)

Electric Focusers for ETX®

Meade-engineered for smooth, rapid focusing with ETX-90, -105, or -125. Four-speed operation from coarse to microfine. Standard-equipment hand controller accepts one 9v. (user-supplied) battery and focuses all ETX telescopes. Or focus through the telescope's Electronic Controller (EC) or through Autostar.

#1244 Electric Focuser for all ETX-90 and ETX-105 models:
$119.95 (6.85)

#1247 Electric Focuser for ETX-125 models:
$119.95 (6.85)

HOW TO ORDER

Prices shown are suggested U.S.A. mail-order retail prices and do not include any applicable sales taxes. Suggested shipping and handling charges to the 48 states by U.P.S. or U.S. Mail shown in ( ) next to each price. **The following national mail-order dealers carry all Meade accessories in-stock for immediate shipment:**

ASTRONOMICS, Norman, OK.
Orders: 800-422-7876; Info.: 405-364-0858.

FOCUS CAMERA, Brooklyn, NY.
Orders: 800-221-0828; Info.: 718-436-6262.

LUMICON, Livermore, CA.
Orders: 800-767-9576; Info.: 925-447-9570.

OCEANSIDE PHOTO & TELESCOPE, Oceanside, CA.
Orders & Information: 800-483-6287.

RIVERS CAMERA, Dover, NH.
Orders: 800-245-7963; Info.: 603-742-4888.

SHUTAN CAMERA & VIDEO, Chicago, IL.
Orders & Info.: 800-621-2248; IL: 847-367-4600.

Canada:

EFSTONSCIENCE, Toronto, Ontario.
Orders & Information: 416-787-4581.

KHAN SCOPE CENTRE, Toronto, Ontario.
Orders & Information: 416-783-4140.

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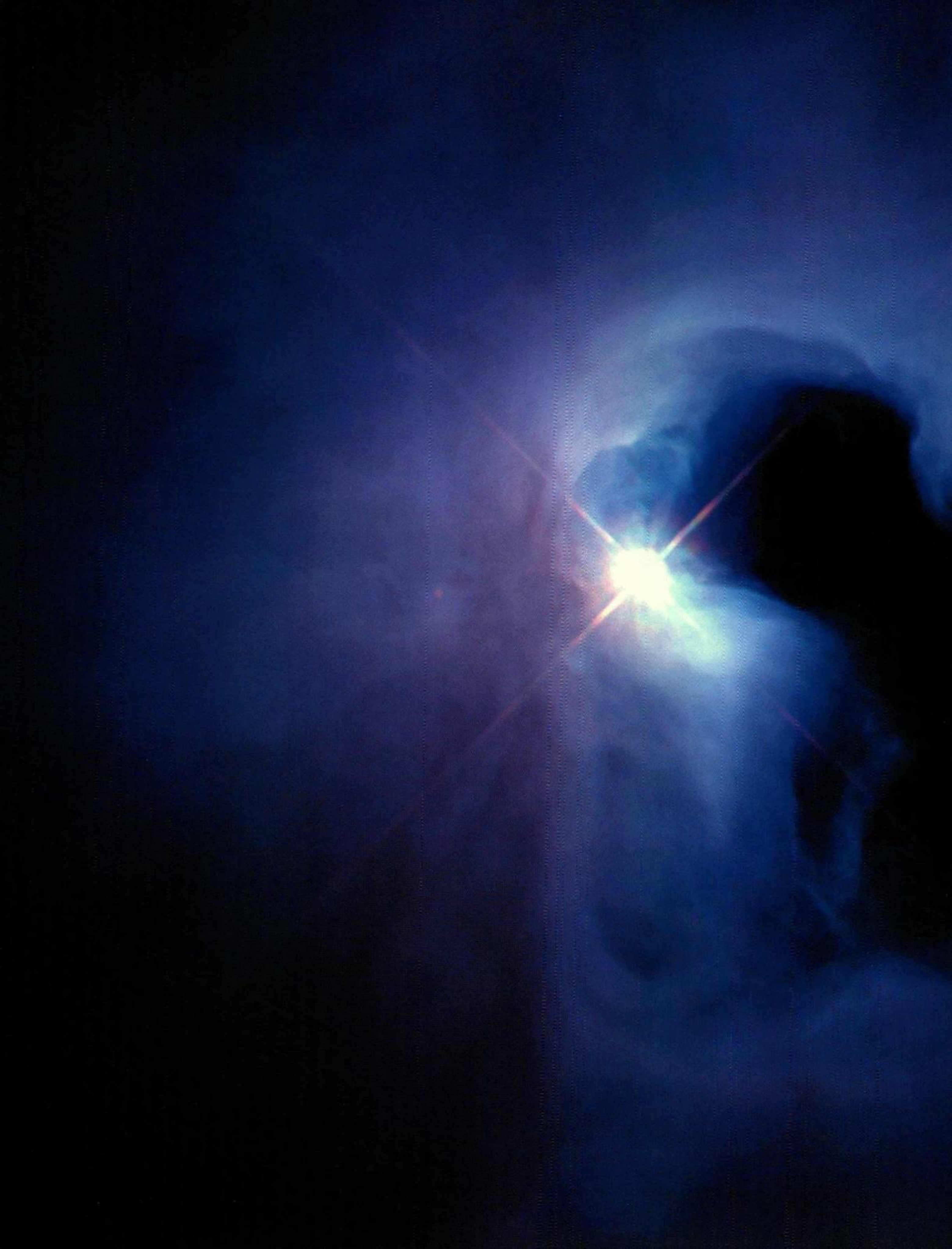

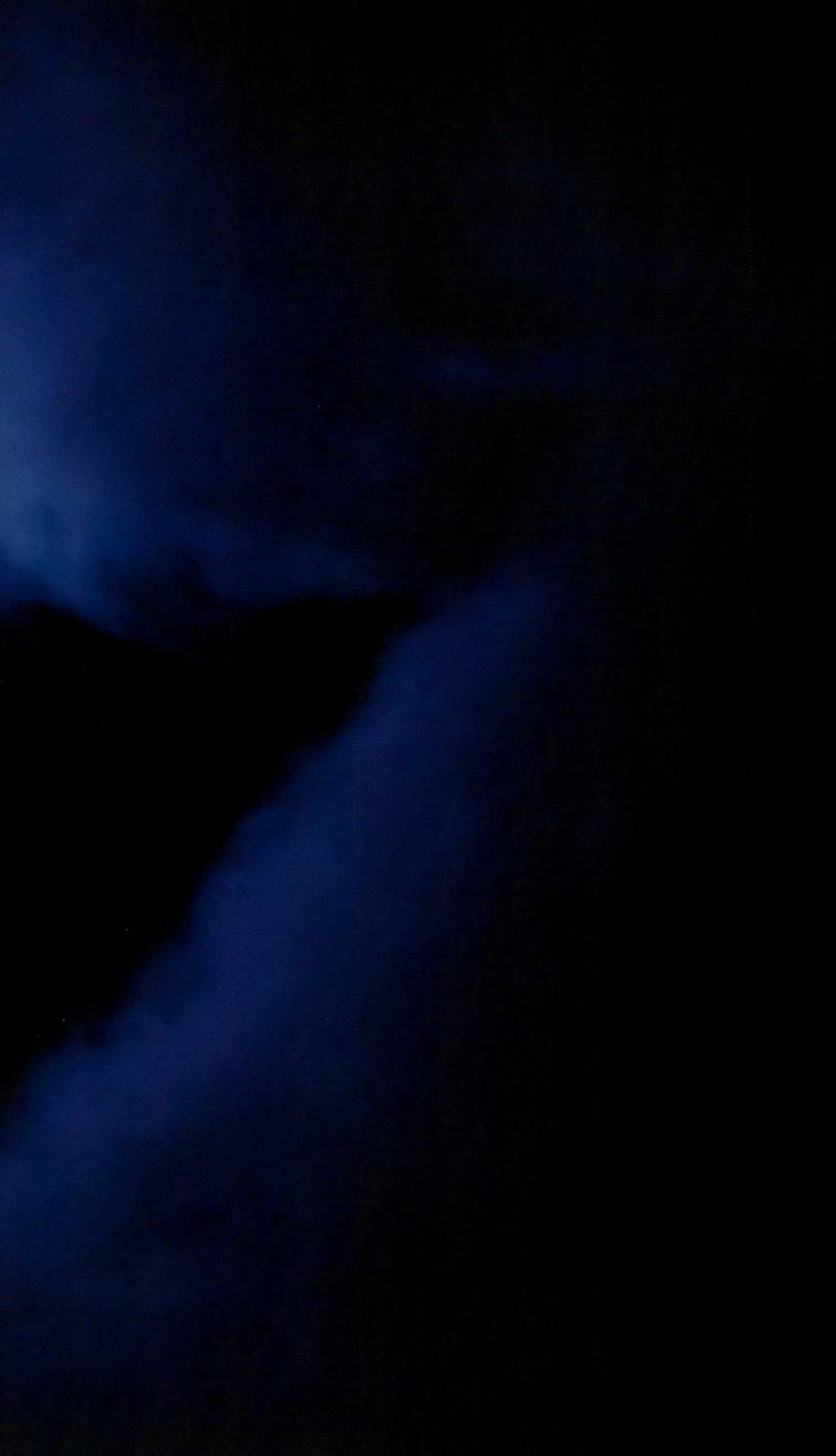

sky Gem

Night and Day

A stark contrast of radiance and murk sets NGC 1999 apart from other reflection nebulae. In addition to its smoky brilliance, fueled by scattered starlight from nearby V380 Orionis (left of center), NGC 1999 harbors a dense globule of cold, obscuring gas, molecules, and dust, which could shroud several newborn stars of its own.

NASA and the Hubble Heritage Team (STScI/AURA)

ORION
TELESCOPES & BINOCULARS

Hundreds more products online!
telescope.com

TELESCOPES

The New Orion SkyQuest™ XT Dobsonian Telescopes

The Best Get Even Better With New Features and Lower Prices

Our popular SkyQuest XT's just got even better with new features such as upgraded Sirius Plössl eyepieces and navigation knobs. Yet they still have the same great performance.

SkyQuest XT4.5
Just the right size for younger stargazers, and incredibly easy to master! Adults will love it too, for its portability and crisp optical performance.

Steel tube, 114mm center marked mirror (f.l. 910mm, f/8), 1.25" aluminum R&P focuser, 5" flanged altitude hubs, CorrecTension Friction Optimization, built in handle, dust cap, Weight: 17.2 lbs. (tube and base). Now With: 6x26 correct-image finder scope, 25mm (36x) and 10mm (91x) Sirius Plössl eyepieces, navigation knob, eyepiece rack, and collimation cap.

$199

SkyQuest XT6
The overachieving XT6 will show Jupiter's Red Spot, Saturn's Cassini Division, hundreds of clusters and nebulas, and galaxies tens of millions of light-years distant. Nicely portable and very affordable

Steel tube, 150mm center marked parabolic mirror (f.l. 1200mm, f/8), 1.25" aluminum R&P focuser, 6x30 achromatic finder scope, eyepiece rack, navigation knob, 5" flanged altitude hubs, CorrecTension Friction Optimization, dust cap, Weight:38 lbs. Now with: 25mm (48x) and 10mm (120x) Sirius Plössl eyepieces (1.25"), navigation knob, and collimation cap.

$349

NOW WITH 2" FOCUSER

SkyQuest XT8
The XT8's prodigious performance on both solar system and deep-sky denizens have made it the telescope of choice for thousands of astronomers, from beginners to die-hard hobbyists.

Steel Tube, 203mm center marked parabolic mirror (f.l. 1200mm, f/5.9), 6x30 achromatic finder scope, eyepiece rack, 5" flanged altitude hubs, CorrecTension Friction Optimization, dust cap, Weight: 43 lbs. Now with: 2" aluminum R&P focuser, 25mm (48x) and 10mm (120x) Sirius Plössl eyepieces (1.25"), navigation knob and collimation cap.

$479

StarMax™ EQ Compact "Mak" Telescopes

The Orion StarMax series brings top-quality Maksutov designs to the amatuer astronomer at an affordable price. All StarMax models feature correct-image finder, EQ mount, and soft-carrying cases for the optical tube.

StarMax 90 EQ
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An Unforgettable Show

Thank you for your feature on the Leonids (Hot Shots, March 2002.) The photos amazed me, and reminded me of a wonderful experience. My new bride and I were in Maui on our honeymoon, and watched the meteor shower on top of Haleakala, where we also planned to watch the sunrise. It was the most beautiful display I have ever seen. We saw 300 to 400 meteors over a few hours, ranging from faint streaks to brilliant fireballs. Just a minute before the sun rose over the clouds in the east, one last fireball streaked, trailing, from the west in dazzling colors and exploded about 45° from the sun. We were in awe. It was a night we will never forget. — *Scott and Roberta Wayne, Slatington, Pennsylvania*

In November 2001, Leonid meteors put on a dazzling show over Appelgate, California. Jack Sales

Predicting our fate

Michio Kaku artfully forecast the future of civilizations in the universe ("Who Will Inherit the Universe?" February 2002.) However, when he says that since ice ages cycle in tens of thousands of years and are therefore not a contemporary worry, he may be wrong. Deep ice cores from Greenland and Antarctica have revealed that the last ice age began suddenly, preceded by wild swings in temperature that, in turn, were preceded by a greenhouse event — an apparent critical temperature threshold that throws the climate into oscillation and then precipitously into a deep freeze. And it ended so abruptly that the transition may have been measured in months or even weeks. So global warming might ironically and tragically put us on ice. — *Ivan Dryer, Van Nuys, California*

You are correct in that ice ages may occur much more suddenly than previously thought. Most meteorologists believe that small oscillations in Earth's spin in its orbit around the sun may be a major contributing factor to ice ages, but the wild card may be human interference with the atmosphere. However, ice age prediction is still a black art. One can argue precisely when the next may occur, but most meteorologists believe that it is inevitable. At present, no technology can prevent an ice age, and our fossil burning may hasten its arrival.

The article, however, points out that a mature Type I civilization, possessing planetary energy, may be able to prevent an ice age from happening, or at least lessen its effects. The question for us is whether our Type 0 civilization possesses the wisdom to solve our political differences so that we can achieve Type I status. The transition from Type 0 to a Type I civilization is perhaps the most precarious, because we still possess all the savagery and sectarian and fundamentalist differences inherited from the forest. The transition from Type I to Type II, thousands of years in the future, should be much smoother, since we will have had millennia to solve our planetary differences. — Michio Kaku, City University of New York

On the dark side?

I enjoy reading *Astronomy* and recommend it to my students. However, in the April 2002 issue, a common error appears in the AstroNews "Event Horizon" section. Although I understand what the author meant by referring to the "dark side of the moon," this phrase keeps a common misunderstanding alive; I spend a lot of time explaining to students that the moon has no dark side. The correct phrase is "the far side of the moon." — *Dan Goins, Martinsville High School, Martinsville, Indiana*

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MARS ODYSSEY MISSION

Spacecraft Hints at a Watery Mars

Wasting no time, the 2001 Mars Odyssey spacecraft started making discoveries within days of February 19, when it reached its final orbit 250 miles (400 km) above the planet. Mission scientists could barely contain their excitement when Odyssey's first observations suggested a significant amount of water ice lurks just beneath the Red Planet's surface.

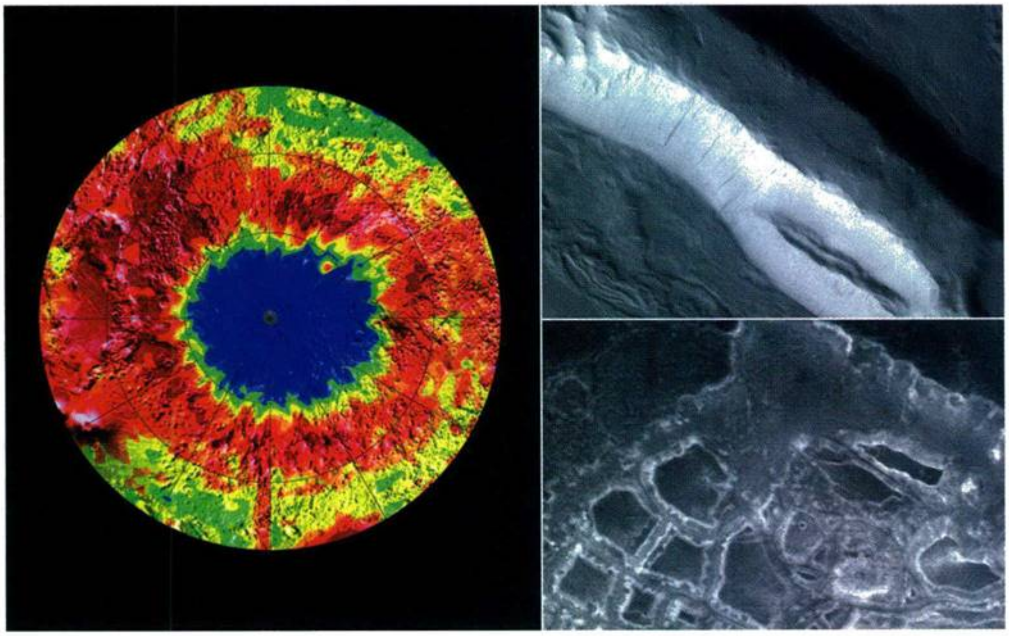
"We are delighted with the quality of data we're seeing," says Project Scientist Steve Saunders of NASA's Jet Propulsion Laboratory. That's a welcome change from the mood that gripped NASA after its two previous missions, Mars Polar Lander and Deep Space 2, failed upon arrival in December 1999. Now Odyssey and its high-tech instruments appear destined to atone for those failures. The spacecraft joins Mars Global Surveyor — which has returned more than 100,000 high-resolution images since it reached Mars in 1997 — to give planetary scientists two sets of eyes exploring the Red Planet.

The evidence for water ice comes from Odyssey's Gamma Ray Spectrometer, a suite of three instruments designed to study gamma rays and neutrons given off by elements on and just below the martian surface. All three instruments show significant concentrations of hydrogen in the top few feet of the south polar regions. The hydrogen likely resides in water ice, although the scientists can't yet quantify how much ice exists there.

"If this is confirmed, it's fantastic," says William Boynton of the University of Arizona, Principal Investigator of the Gamma Ray Spectrometer. "There is the equivalent of at least several percent water south of 60° south latitude." Planetary scientists have speculated for years that water may exist near the surface of Mars, but the new observations are the first to directly detect the hydrogen that likely traces the water's distribution.

The spectrometer works by measuring the results of cosmic ray impacts with the martian surface. Cosmic rays continually smash into the atoms that make up the soil and rocks, liberating neutrons in the process. These neutrons then scatter and collide with other atoms. Hydrogen turns out to be very effective at slowing down these neutrons, which is how the spectrometer detects it. The collisions also excite the atoms, which release the extra energy by emitting gamma rays at specific wavelengths depending on the atom.

Odyssey's other main instrument is the Thermal Emission Imaging System, or THEMIS, which takes images at both visible and infrared wavelengths. The images will help scientists map the global distribution of minerals on the martian surface. The initial set of images released by NASA were taken during the mission's first 10 days.



NASA/JPL/University of Arizona/Arizona State University

New views from NASA's Mars Odyssey spacecraft give good evidence for water ice on the Red Planet. Left: Deep-blue hues, captured by the neutron spectrometer high above the martian south pole, indicate hydrogen-rich soil. Top right: A visible-light, THEMIS image of the Acheron Fossae region is helping scientists track minerals. Bottom right: An infrared image of the Hydaspsis Chaos region shows features that may have formed when subsurface water or ice was carried away.

The infrared images record heat radiated back into space by the sun-warmed surface and so can record Mars both during the day and at night. They have a much higher resolution than those from a similar instrument onboard Global Surveyor. On the other hand, the visible-wavelength images have a resolution of only about 60 feet (18 meters) — compared with just a few feet for those from Global Surveyor. The Odyssey images will help bridge the wide gap between Surveyor's images and the larger scale images taken by the 1970's Viking orbiters. — RICHARD TALCOTT

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X-RAY ASTRONOMY

Hot Spot Puzzles Astronomers

▶ It seems that fresh x-ray observations of Jupiter are putting theorists on the spot.

When Southwest Research Institute astronomer Randy Gladstone and his colleagues targeted the king of the solar system with NASA's Chandra X-ray Observatory, they were trying to solve problems, not create them. Nonetheless, Gladstone and his team pinpointed the location of Jupiter's well-known x-ray hot spot with unprecedented precision, only to find that current theories implode when it comes to explaining how the spot got there.

"The [exact] location of the x-ray hot spot effectively retires the existing explanation for Jupiter's x-ray emission," says Gladstone.

The old picture looks something like this: Renegade, energized oxygen and sulfur ions (cast from the surface of the jovian moon Io) rain down on Jupiter's atmosphere, producing the observed x-ray emission.

But the new, high-resolution Chandra observations also show that the hot spot is much closer to the jovian north pole than previously believed. With no clear ion pathway from Io to high jovian latitudes, it seems impossible that Io could be the source. In addition, Gladstone and his team found that the ion source must be much farther away — at least 30 times the radius of the giant planet — than Io.

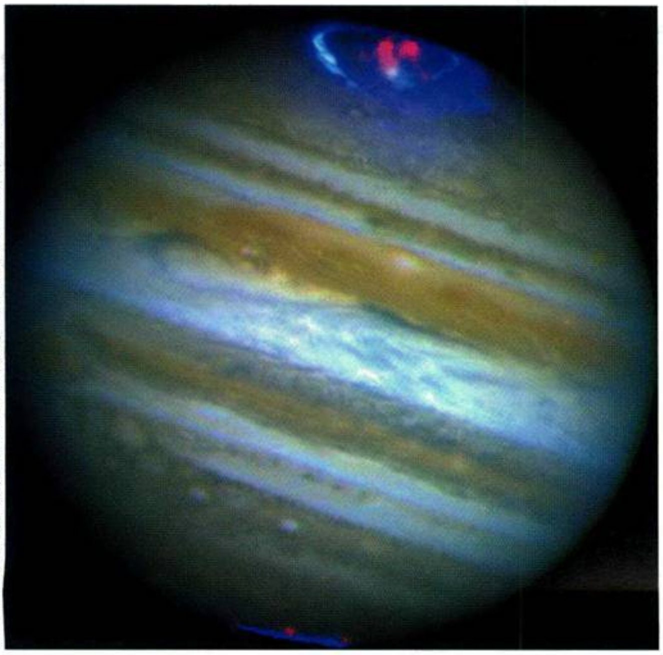
Astronomers are now considering the sun as a possible source of oxygen and sulfur ions to fuel Jupiter's x-ray hot spot. But this idea also has problems.

While it's probable that heavy particles flowing from the sun are captured by Jupiter's enormous magnetosphere, it's not clear that there are enough particles to account for the measured hot-spot emission. What's more, once trapped in the magnetosphere, the ions could funnel toward the jovian poles and oscillate back and forth.

But there's still no direct evidence that fluctuations in the solar wind show any correlation to hot spot emission, or to its observed 45-minute period of oscillation.

— William Schomaker

A composite x-ray (magenta), uv (blue), and optical image clearly displays Jupiter's polar hot spot.



X-ray: NASA/SWRI/R. Gladstone. UV: NASA/HST/J. Clarke. Optical: NASA/HST/R. Beebe

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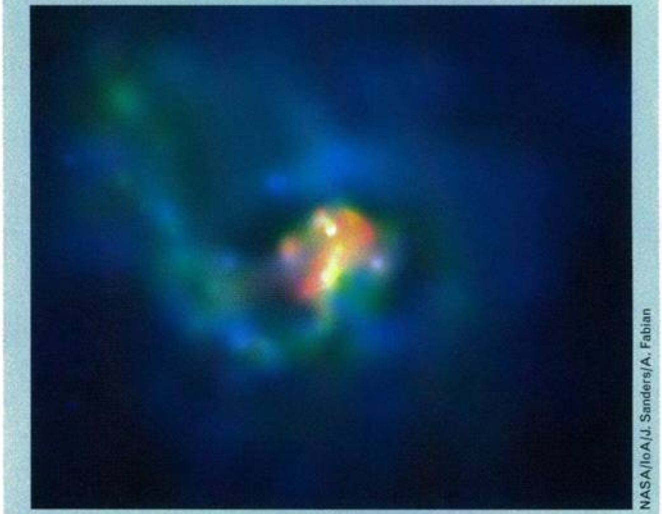

NASA/IoA/J. Sanders/A. Fabian

A WINDING, TWISTED SHEET OF BLISTERING GAS erupts 70,000 light-years from the center of the Centaurus galaxy cluster. This temperature-coded map, produced by NASA's Chandra Observatory, is giving astronomers a new view of the cluster's central regions. Containing the mass of one billion suns, the relatively cool — blue colors correspond to increasing temperature — gas is believed to be the by-product of a massive galaxy collision or that of rapid cooling of gas falling onto the core of the cluster.

BLACK HOLES

New Source of Gamma Bursts

▶ Astronomers have long puzzled over the origin of gamma-ray bursts (GRBs), which in only a snap of a finger outshine the sun over its 10-billion-year lifetime. Just recently, though, evidence has popped up in a computer model that these incredibly explosive events result from a last-ditch struggle between a black hole and its companion star. In addition, these monstrous bursts might be just a small fraction of the total energy released by the warring partners.

The model depicts a "Kerr black hole" (named after Roy Kerr, a crackerjack mathematician from New Zealand who in 1963 solved Einstein field equations for a spinning black hole, soon known as the "Kerr Solution"), which is just one type of an assortment of theorized black holes.

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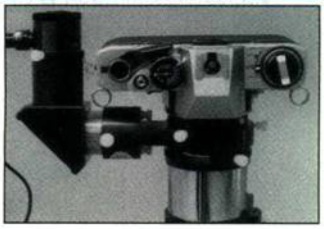

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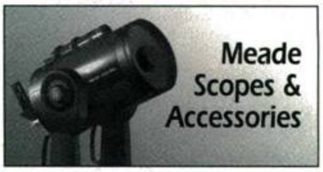

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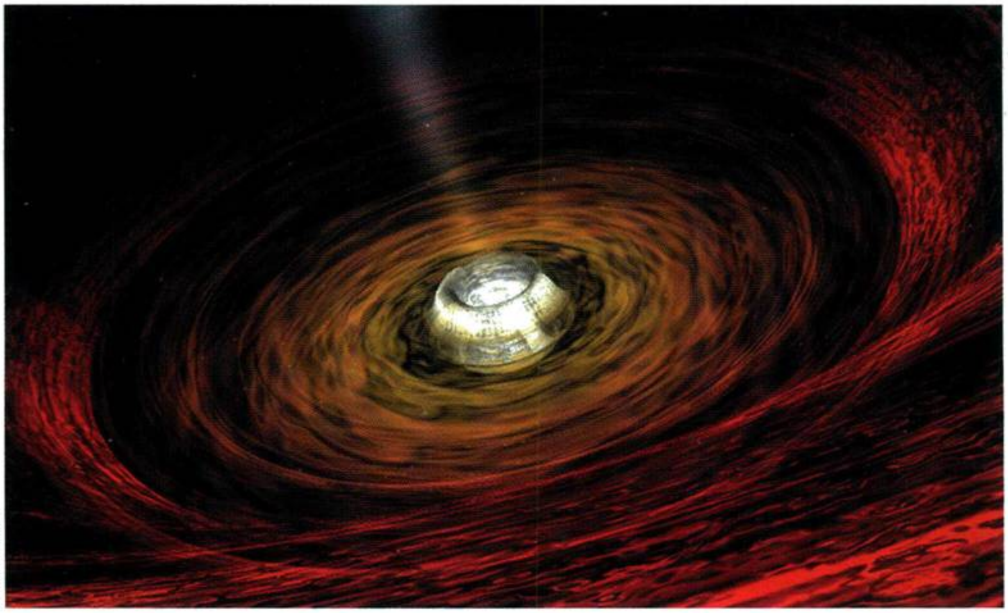


CXC/A. Hobart

Rotating black holes may be the key to solving astronomy's gamma-ray burst mystery.

According to Maurice Van Putten — an assistant professor in mathematics at MIT who helped design the model in a partnership with researchers from Israel's Tel Aviv University — his digital simulation of a Kerr black hole resolves an observational paradox surrounding GRBs and black holes: Kerr black holes can release vast amounts of energy in all directions, but GRBs are believed to arise from focused beams of moderate energy.

Van Putten believes that prior to a GRB event, a Kerr black hole's companion star is reduced to a donut-like ring, or torus, which then spins wildly on the black hole's accretion disk. As the black hole gobbles up the stellar remnants, in roughly 20 seconds, beam-like jets of gamma rays suddenly appear along the black hole's rotational axis. However, most of the black hole's energy — nearly 100 times more — is emitted omnidirectionally from the dwindling torus as gravity waves.

Though this computer simulation reveals that Kerr black holes release energy in two forms, gamma rays and gravity waves, astronomers have only had the technology to "see" gamma-ray emissions. But if his model is correct, Van Putten predicts the land-based observatory LIGO (Laser Interferometer Gravitational-wave Observatory), might detect "dark" gravity wave emissions from a black hole within the next decade.
— Paul Morledge

SPACE WEATHER

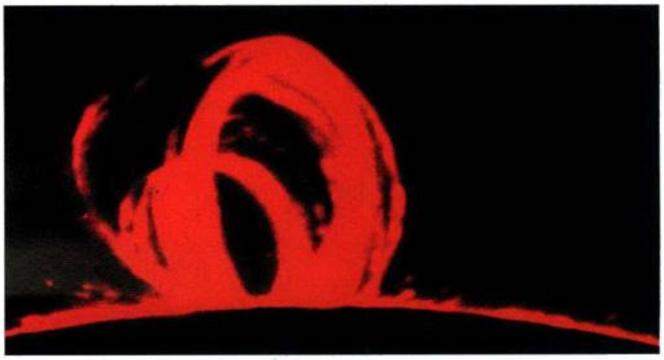
Power Costs Surge with Sun?

▶ Solar storms are usually something for skywatchers to get excited about. After all, they are the root cause of the beautiful displays of dancing color seen in the northern and southern lights. Yet a handful of satellite malfunctions and widespread power grid failures in the last several decades have also shown that solar storms can deliver more deleterious effects. Now according to one researcher, space weather may even play a part in raising electricity costs across the planet.

The National Science Foundation recently awarded Kevin Forbes, associate professor and chair of the Department of Business and Economics at the Catholic University of America, a $30,000 grant to study the effects of space storms on power prices. Forbes will analyze three months' worth of data (spanning June 1, 2000 to August 31, 2000) from two sources: space storm records from the World Data Center for Geomagnetism in Kyoto, Japan, and wholesale electricity prices from the Pennsylvania-Jersey-Maryland (PJM) Interconnection, the largest power pool in North America.

After preliminary matches of DST (Disturbance Storm-Time) data from the World Data Center with hourly data from PJM, Forbes believes that he's already discovered a clear correlation between solar activity and power prices. As the DST values decrease and the storm's intensity increases, the power grid's performance seems to have dropped while electricity prices rose. (Negative DST values indicate strong solar storm activity.) For example, during one storm in mid-June, 2000, the DST index dropped by 500 percent in two hours, causing the cost of electricity to leap from $15 per megawatt to about $68 per megawatt. And while it appears that the effects of these storms won't show immediately on consumer energy bills, Forbes believes extra costs are eventually passed on.

"In the past year or so, electricity markets have been buffeted by higher



NOAO/AURA/NSF

Could the sun's magnetic fury eventually spawn a global economic crisis?

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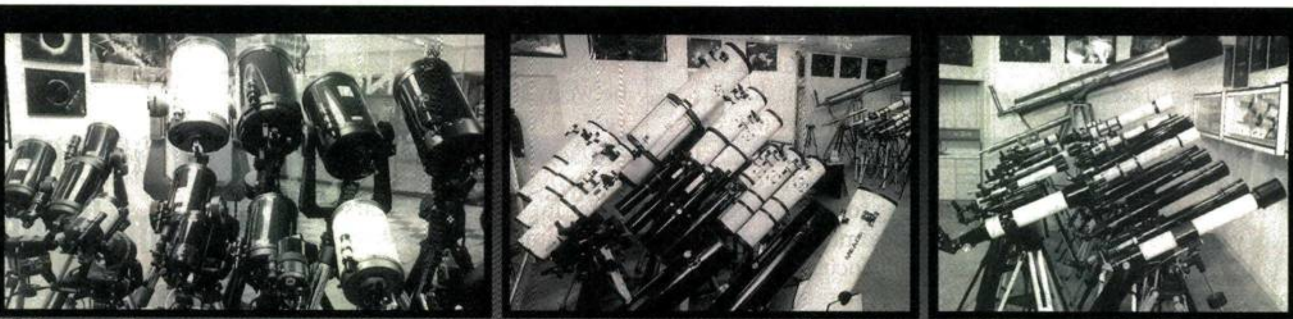

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prices of natural gas," says Forbes. "What this analysis seems to suggest, however, is that there's something else going on, and part of that something else has to do with events in space. If we show that these [storms] really do matter, at some point there's going to be more of an effort to forecast the storms."

When his grant expires in September 2002, Forbes plans to submit a report to the National Science Foundation to familiarize policy-makers with space-weather and its potential influence on the economy.

— Elesa Janke

PLANETARY SCIENCE

Earth's Early Days Revisited

▶ Asteroids, not comets, very likely resurfaced Earth shortly after its formation with a bombardment so severe it erased any geologic formations older than 3.9 billion years. David Kring of the University of Arizona Lunar & Planetary Laboratory, together with University of Hawaii researcher Barbara Cohen, recently reported in the *Journal of Geophysical Research* that they believe this same asteroidal sand-blasting effect resurfaced Mars, Mercury, Venus, and the moon during the same cataclysmic period.

Analyses of lunar meteorites and data on lunar impact melt ages reveal a more or less uniform disruption and metamorphism of the moon's crust within a relatively short amount of time. Given the close proximity of the moon and Earth, scientists studying both generally assume that whatever happens to one affects the other in a similar manner. Key evidence points to discrete metal particles and elemental signatures that imply a large — and once hot — source for the objects behind the impacts; this scenario favors asteroids and pretty much rules out comets.

Kring and Cohen also credit this rain of asteroids with pounding out craters on planets throughout the inner solar system, including Mercury, Venus, and Mars. They cite a dynamical source for the bombardment material as an asteroid belt in heliocentric orbit.

And while they theorize that most of Mars's still-visible southern hemisphere craters formed as a direct result of the bombardment, more recent geologic changes (that is, any that occurred fewer than 3.9 billion years ago) mask any evidence of craters on Venus, say Kring and Cohen.

Another factor contributing to the idea of surface bombardment by asteroids focuses on impact-generated hydrothermal systems and their effects on the pre-biotic chemical environments found within. The formation of these hot-water "incubators" coincides with isotopic evidence indicating that life forms began evolving on Earth roughly 3.9 billion years ago.

Overall, Kring and Cohen estimate that the influx of asteroids produced more than 22,000 impact craters on Earth with diameters ranging from 12.5 to 3,100 miles (20 to 5,000 km) wide. They also believe that the pelting lasted for between 20 and 200 million years. They speculate that the largest of these events vaporized oceans or surface water for up to 1,000 years while simultaneously delivering huge amounts of biogenic materials to Earth.

— Carol Ryback

New research indicates that asteroids like 243 Ida once pelted a nascent Earth.

NASA/JPL

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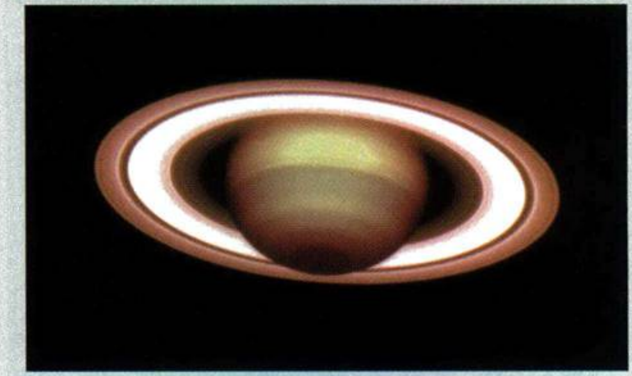

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little star is either on the verge of setting a cosmic speed record or provoking the review of a stellar theory.

Located 20,000 light-years away, SGR1900+14 is one of just four intensely magnetic neutron stars positively identified in the Milky Way Galaxy. Called magnetars, they are suspected to be the remains of stars that have recently gone supernova and are also believed to be the culprits behind soft gamma repeaters (SGRs).

As if that's not enough, preliminary results indicate that SGR1900+14 may be speeding through space at more than a million miles per hour.

Typically, a supernova explosion leaves behind an expanding shell of material called a supernova remnant and a dense, city-sized corpse called a neutron star. For reasons astronomers don't yet understand, some supernovae evidently produce highly magnetic neutron stars.

"Normally, when you discover a magnetar, you look for the nearest supernova remnant and assume that is its birthplace," says University of California physicist Kevin Hurley, who heads a team studying SGR1900+14.

"In this case, though, we have a problem."

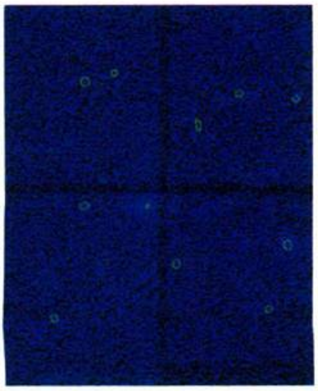
The nearest supernova remnant to SGR1900+14 is at least 15 light-years away. And according to Hurley's group, that supernova remnant is probably 10,000 years old or less; otherwise it would have dissipated from view by now.

If SGR1900+14 came from this suspected supernova remnant, it must be traveling at least 10 million miles per hour to have moved so far away.

Determining the magnetar's speed is a difficult task. Unfortunately, the star is optically faint, and except for an outburst several years ago, is also radio-quiet.

To calculate its movement over time, Hurley's team is comparing the magnetar's position during its radio outburst with its placement in recent observations by the Chandra X-ray Observatory. Additionally, the group must accurately measure any motions of background objects for comparison. According to Hurley, the task will take months.

If the researchers learn that SGR1900+14 isn't speeding away as madly as they suspect and wasn't created with the nearest supernova remnant, astronomers will have to come up with a new way to explain how such magnetars are born. — VANESSA THOMAS



NASA/UC-Berkeley/K. Hurley

SGR1900+14 lies below and left of center in this Chandra x-ray image. Astronomers still need to corroborate the positions and velocities for neighboring sources (green circles) to confirm the magnetar's rapid retreat.

For the latest astronomy news as it breaks, visit us at www.astronomy.com

Correction: Coloring the Cosmos

"We live in a turquoise universe," declared some astronomers earlier this year. But don't rush out and purchase new clothes to match — the researchers now say they were foiled by a bug in the computer code used to reach this verdict. Now they claim the cosmos is really beige. In what started out as a gimmick to call attention to their mainline research, astronomers Karl Glazebrook and Ivan Baldry of Johns Hopkins University calculated what they refer to as the "Cosmic Spectrum," which the duo described as the average color that observers would see if they had the universe in a box and could see all its light at once. To make matters easier, though, they assumed the cosmic objects in their sample were all stationary, thereby negating the color-blurring effect of Doppler-shifted light.

Pioneer 10: Still Truckin'

After more than three decades in space, NASA's Pioneer 10 spacecraft is alive and kicking. The craft was the first man-made object to pass through the asteroid belt and the first to leave the solar system in 1983. Now, five years after the official close of the mission, NASA officials have contacted the probe, 7.4 billion miles away on its way toward the constellation Taurus. On March 1, 2002, controllers at NASA's Deep Space Network sent a signal and crossed their fingers. Because they've lost contact in the past, most recently in August 2000, they weren't sure what to expect. But twenty-two hours later, Pioneer 10's response was collected at the 230-foot (70-meter) DSN dish in Madrid, Spain. At its current rate of departure, officials expect Pioneer 10 to pass its first star in about two million years.

NASA

NASA's 230-foot (70-meter) Deep Space Network dish.

A New Ozone Hole in the North?

New NASA research indicates that Earth's tenuous layer of ultraviolet-blocking ozone may soon develop another hole to match the one scientists have been tracking over the South Pole. According to Azadeh Tabazadeh at NASA's Ames Research Center at Moffett Field, California, severe volcanic eruptions over the next 30 years could spur the formation of a matching ozone hole over the North Pole. When major eruptions occur, large concentrations of sulfur are pumped high into the atmosphere, thereby destroying precious ozone. Tabazadeh and her colleagues fear that a hole over the North Pole may be more harmful in the long run, because more people actually live in Arctic regions than in Antarctic regions.

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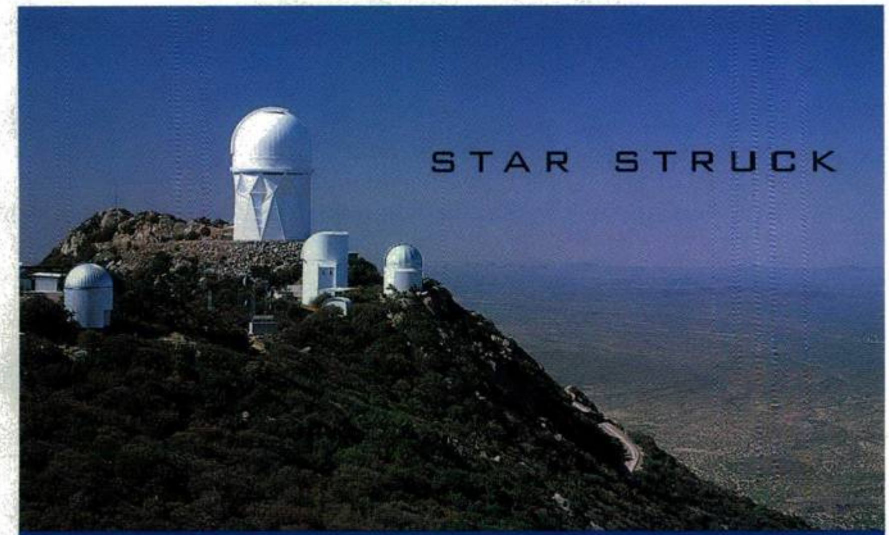

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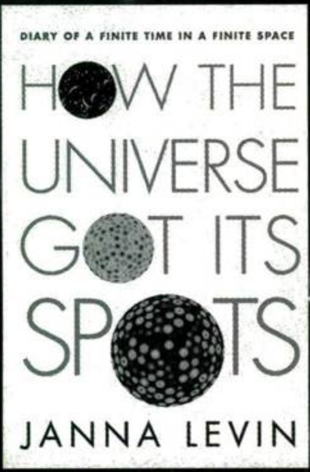

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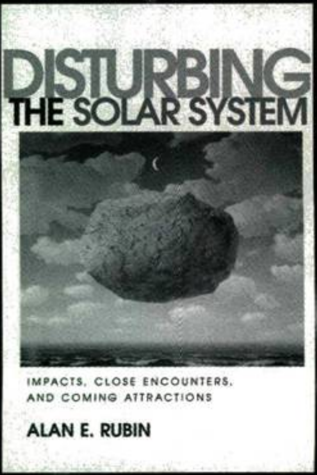

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Beyond Black

How will astronomers finally confirm the existence of black holes beyond a reasonable doubt?

by Ray Jayawardhana

WHILE THE PROSECUTION'S CASE HAS BEEN STRENGTHENED BY observations of strange, inexplicable behavior at the hearts of many galaxies and binary star systems, the truth is that the best evidence for the existence of black holes is still hardly more than circumstantial. In fact, proof of their existence comes by default: Theorists cannot contrive a better explanation for the behavior of seemingly gargantuan objects harboring the mass of millions of suns at the centers of dozens of galaxies, or the invisible companions of run-of-the-mill stars that appear so dense they defy other explanations. Today, as for the last several decades, astronomers are searching for incontrovertible proof that black holes are real — something unique to these beasts alone.

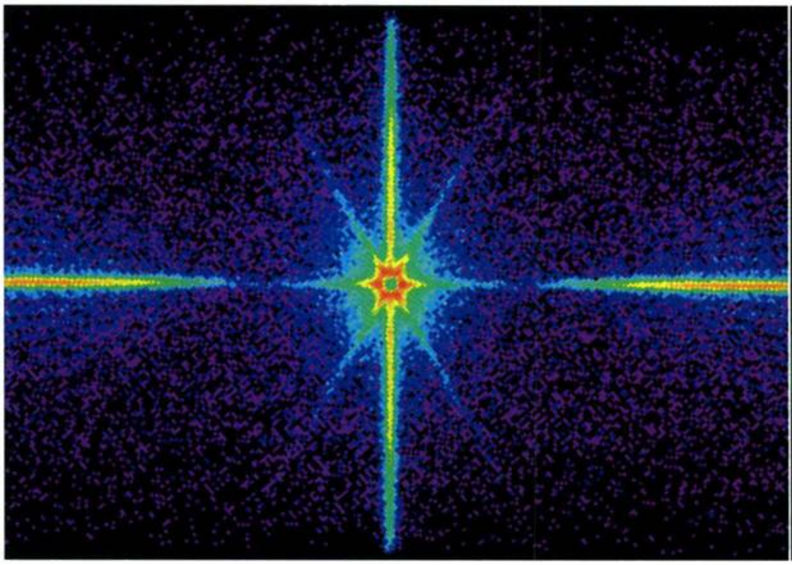
While black holes sound complicated and exotic, in fact they are about as simple as things get. Whereas people, planets, and Porsches are all made up of lots of atoms arranged in complex ways, a black hole consists of just two parts — a central point called the singularity and an imaginary surface surrounding it known as the event horizon. The event horizon marks the point of no return: Anything that crosses it, including light, has no escape (hence the name black hole). This is because a huge concentration of mass crammed into the confines of a mathematical point causes such a sharp warping of space-time that the singularity becomes shut off from the rest of the universe. What's more,

Mehau Kulyk/SPL/Photo Researchers, Inc.

there are few external markings of a black hole that astronomers can hope to detect; the only salient features are its mass and how fast it rotates.

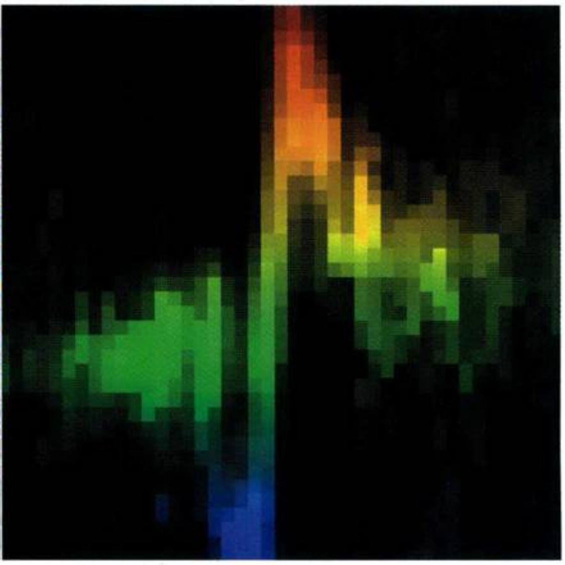
Stuck Between Extremes

To confuse matters slightly, astronomers also know that neutron stars can mimic some properties of black holes. A neutron star is essentially a ball of neutrons about the size of a city, formed when a dying star's gravity compresses matter to extreme densities. A one-solar-mass neutron star is roughly the same size — 37 miles (60 km) across — as a 10-solar-mass black hole. Material falling onto both bodies would be heated to high temperatures and give out x rays on its way down. So it isn't easy for astronomers to tell a black hole and a neutron star apart — at least not from a great distance.



Today's best evidence that black holes are real comes from spectra. High-energy x rays flanked by low-energy compatriots (left) strongly suggest the presence of an accretion disk in the black hole binary XTE J1118+480.

NASA/CfA



The characteristic S-shaped spectrum found at the center of galaxy M84 (right) indicates that gas there is spiraling in at nearly one million miles per hour.

NASA/NOAO

Still, two characteristics distinguish black holes from neutron stars. Neutron stars, according to Einstein's Theory of General Relativity, cannot have masses greater than about three times that of the sun; a more massive stellar cinder would inevitably collapse into a black hole. Over the past decade, astronomers have inferred the masses of invisible companions in x-ray-emitting binaries by measuring the tiny Doppler shifts in the spectrum of the normal star. In at least seven cases, the mystery object turns out to be too massive to be a neutron star. "A black hole is the simplest and most economical way to account for these massive unseen companions," says Charles Bailyn of Yale University. "What else could they be?" concurs Harvard University theorist Ramesh Narayan.

Of course, that isn't conclusive proof of the existence of black holes. As Narayan admits, "It's *still* a process of elimination." These monsters are too massive to be neutron stars so they must be black holes, goes the argument. Perhaps an even more bizarre object, possibly one made of "strange matter," could be the culprit. The most unique feature of a black hole is that it lacks a hard surface. The event horizon isn't marked by a physical boundary; it's a virtual demarcation between two regions of space eternally separated from each other. If astronomers could find event horizons, they would have the best evidence for black holes yet.

On the Hunt for Horizons

Recently, Michael Garcia of the Harvard-Smithsonian Center for Astrophysics and his colleagues used the Chandra X-ray Observatory to study a dozen x-ray novae — binary systems that occasionally erupt with brilliance when material from a normal star falls onto its invisible companion — that could contain a neutron star or a black hole. By comparing the x-ray novae in their dormant state, Garcia's team found that systems containing a black hole candidate emitted only one percent as much energy as those with neutron stars. "That's just what you'd expect if energy disappears into the black hole along with the infalling gas," explains team member Narayan.

If the collapsed object is a neutron star with a hard surface, a torrent of x rays is released when the material strikes it. But, in the case of a black hole, only a small amount of energy can escape before the material passes through the event horizon and vanishes forever. Narayan likens it to "sitting upstream watching water seemingly disappear over the edge." Garcia adds, "It's a bit odd to say we've discovered something by seeing almost nothing, but, in essence, this is what we have done." He considers the results to be "proof that event horizons exist."

The Heart of the Matter

A similar story holds for hearts of galaxies suspected to harbor massive black holes, including the center of the Milky Way Galaxy. Many of these galactic nuclei are dimmer in x rays than one would expect, considering how much gas must be flowing into them from their immediate

From a distance of 50 million light-years, earthbound astronomers have determined that the Sombrero Galaxy (M104) probably harbors a supermassive black hole at its core. From their estimates the giant black hole could weigh in with the mass of one billion suns or more.

ESO

surroundings. "Most galaxies seem to have highly underluminous nuclei," says Narayan. "There's an energy deficit." The best explanation, again, according to Narayan, is that energy is disappearing along with gas into the black holes in the centers of galaxies.

Mitchell Begelman, a theorist at the University of Colorado in Boulder, agrees that black holes would be dimmer than neutron stars, because the hard surfaces of the latter provide an extra source of radiation. But, he isn't convinced that Garcia, Narayan, and their colleagues have proven the existence of event horizons. One difficulty is knowing just how much gas is falling into the compact object. "It may be that only one percent of the material is actually going in," says Begelman. He admits that "these observations fit our ideas about event horizons in black holes," but adds, "I'd say the evidence is still anecdotal at this point."

Begelman's collaborator, Roger Blandford of Caltech, is also skeptical. According to Blandford, much of the gas, and thus the energy, is carried away by an outflow or a wind, instead of entering the black hole. "I call this altruistic accretion — one proton sacrifices itself so that thousands of its siblings can escape to freedom," Blandford says. As a result, "in a source like the galactic center, the net accretion rate can be orders of magnitude smaller than the mass supply rate, and the emission is correspondingly reduced," he argues. According to Blandford, the black hole would be dimmer — not because most of the gravitational energy vanishes beyond the black hole's event horizon, "but because very little of the gas actually makes it to the horizon."

Measuring the Last Hurrah

Joseph Dolan of NASA's Goddard Space Flight Center in Maryland looked for yet another telltale sign of an event horizon. He pored through observations of the black hole candidate Cygnus X-1 — obtained with the high-speed photometer on the Hubble Space Telescope — in search of the last hurrah of material falling into a black hole. In the summer of 1992, the photometer measured the object's ultraviolet light 100,000 times each second for three hours. For the next few years,

Many astronomers believe that a brilliant x-ray jet, spewing from the core of elliptical galaxy Centaurus A, indicates that a supermassive black hole is lurking there. Current theory suggests that such jets may arise from accretion of matter onto suspected supermassive black holes.

NASA/CXC/SAO

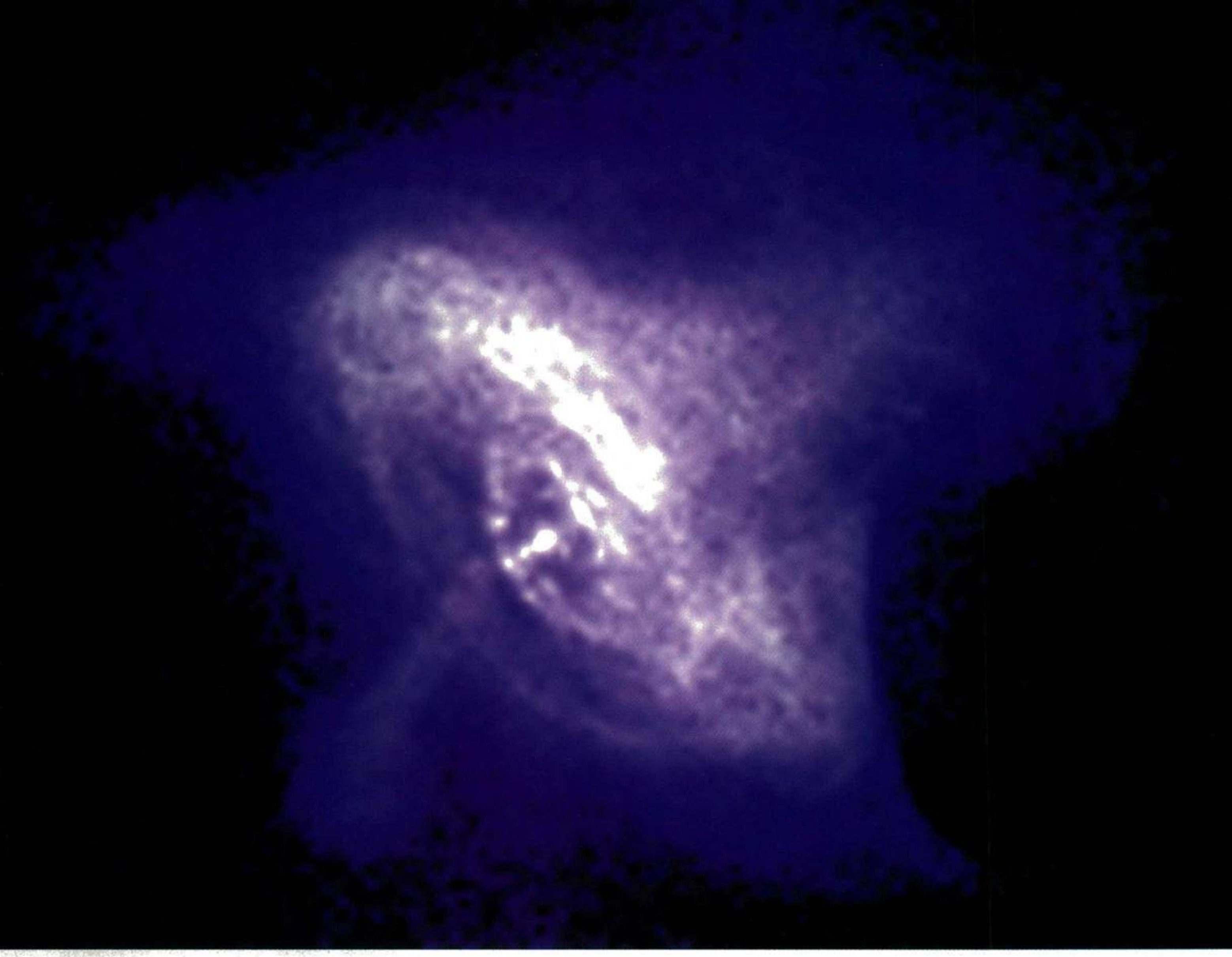
Dolan scrutinized the deluge of data, looking for a "dying pulse train" — rapidly decaying, sequential flashes of light from a hot blob of gas spiraling into the black hole — as suggested by theorist William Stoeger twenty years ago. The separation between the pulses should decrease as the material spirals into the event horizon, in lockstep with the brightness of the pulses. Therefore, the last visible pulse should be the weakest. On the other hand, if the object had a solid surface, like a neutron star, the last pulse would be the strongest as the material slams into the surface.

Last year, Dolan reported that he had found two series of pulses that bear the characteristics of a dying pulse train, and thus the signature of an event horizon. One event had six pulses, the other seven. Each series lasted just two tenths of a second before disappearing altogether. Still, Dolan cautions that with only two events in a heap of data, the detection could be a statistical fluke that mimics the expected signature.

Begelman describes Dolan's work as "a courageous attempt," and agrees that astronomers need to be extremely careful in "pulling a weak signal out of a lot of noise." He points out another complication in interpreting the observations: "Dolan's method works only if there's a thin disk of material that extends very close to the event horizon." If the disk stops farther out, and the infalling gas forms a "corona" around the black hole, the expected pulse pattern would be different. Begelman says Dolan's result is "suggestive but not conclusive." But, he is optimistic about the method's prospects: "Even if you don't see as clean a pulse train as theory predicts, you'll still learn a lot about what's happening very close to the black hole."

Mighty Monsters

There may be a third way to detect the event horizon, at least in the case of the mighty monster at the center of our own galaxy, whose position is marked by a radio source dubbed Sagittarius A*. Back in 1973, physicist James Bardeen described how a black hole would appear against a bright uniform background: It would appear literally as a "black hole." At the time, it was purely a theoretical exercise. Two years ago, following on



Bardeen's lead, Heino Falcke of the Max Planck Institute for Radio Astronomy in Bonn, Germany, and his colleagues performed a realistic calculation of how Sgr A* would distort radio waves passing extremely close to the event horizon. Their simulations show that the black hole would cast a relatively large "shadow" that may be detectable at millimeter wavelengths. "Regardless of the structure of the region around the black hole that we tried in our computer models, we saw a shadow in the simulated images," says Caltech team member Eric Agol.

Detecting the black hole's shadow would require millimeter-wave observations with unprecedented resolution. A technique known as Very Long Baseline Interferometry (VLBI), in which signals from radio telescopes thousands of miles apart are combined to produce an image with greater detail than any individual telescope could, offers the best hope. "With the currently available resolution, we could see a radio source in Los Angeles the size of a mustard seed from Berlin. Now we have to improve things just to the point where we can image a dent on the seed," explains Falcke. With the major radio observatories around the world working together, and some improvements of the technique, Falcke is hopeful such an observation can be attempted in the next few years. How easy it would be to interpret those data, given the messy environment around the galactic center, is still open to debate.

Beyond a Reasonable Doubt

For now, it seems that a lot more work, both on the theoretical and observational fronts, is needed to confirm the existence of event horizons, and thus black holes, beyond a reasonable doubt. Colorado theorist Begelman sums up the current status smartly when he declares, "It's a bit premature to say that we have found proof of black holes. But, so far, the evidence appears to be going in the right direction." ▣

Astronomy *contributing editor Ray Jayawardhana is a Miller Research Fellow in astronomy at the University of California, Berkeley. His research focuses on the origin and diversity of planetary systems.*

X-ray jets can also be found emanating from sites that likely do not contain black holes, making it more difficult for astronomers to distinguish between jet-producing scenarios. This jet, at the center of the famous Crab Nebula supernova remnant, is caused by accretion of matter onto a neutron star rather than a black hole.

NASA/CXC/SAO

Name That Nebula

The night's most beautiful objects cry out for names.

Nebulae, massive clouds of gas and dust in interstellar space, include the most beautiful and brilliantly colored objects in the night sky. The only catch: You need a good pair of binoculars, or much better, a telescope, to see one. Because they are faint and their edges are less distinct than stars or planets, many of these objects appear fuzzy even in large backyard telescopes. The familiar word "nebulous," meaning vague or indistinct, in fact, derives from the word nebula, which comes from the Greek word for cloud.

Ken Blankenship and Dennis Batis

NGC 6559

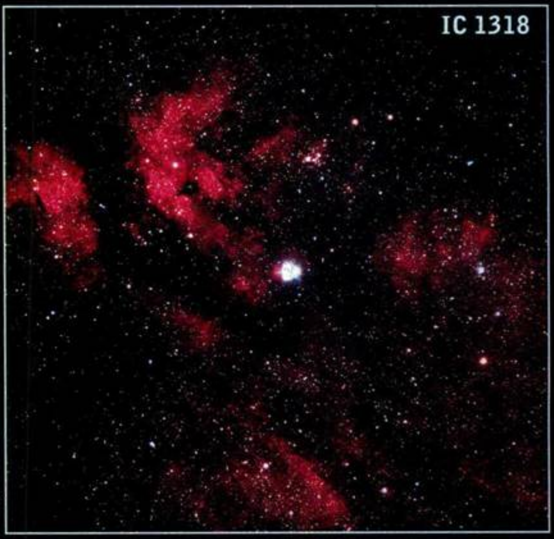
Most people admire nebulae only in photos, many of the most spectacular of which have been captured by the Hubble Space Telescope. But beautiful and mysterious as they are, many nebulae go nameless. And *Astronomy* magazine wants to change all that. We are asking you to help name a few of the dazzling clouds of gas and dust that so far are officially identified only by catalog numbers.

Many of the named nebulae are familiar even to armchair observers. Emission nebulae, such as the Orion Nebula, M42, are clouds of high-temperature gas and dust. Their interstellar material absorbs ultraviolet radiation from neighboring young stars. They then radiate energy as their atoms fall back into lower energy states. Emission nebulae are red because they are most abundant in hydrogen. A great deal of recent and current star birth occurs in these nebulae.

Reflection nebulae are clouds of dust particles that simply reflect light from nearby stars. These, like M78 in Orion, are blue. Hot young stars also grow in reflection nebulae. Sometimes emission and reflection nebulae are paired in particularly brilliant displays, such as in the Trifid Nebula, M20.

Dark nebulae are thick clouds of dust that block the light from whatever might be behind them. The Horsehead Nebula (B33) is a well-loved example of a dark nebula surrounded by emission and reflection, also called diffuse, nebulae.

Steve Mandel



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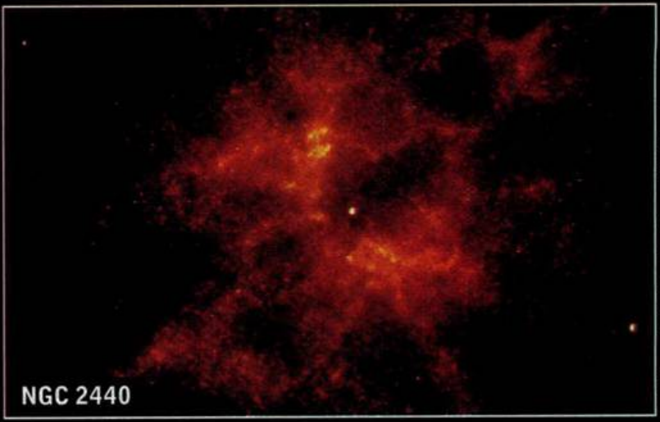

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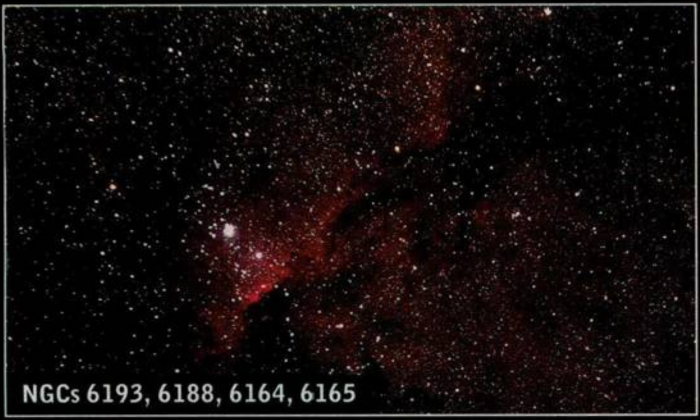

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Luke Dodd

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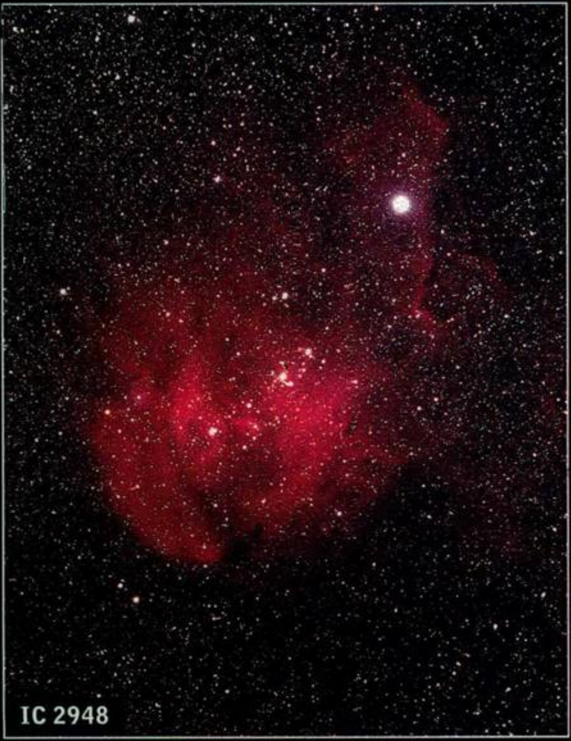

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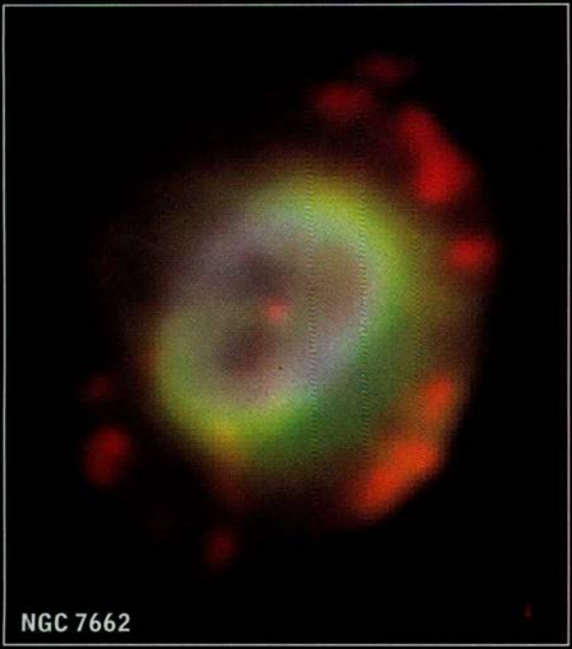


NGC 7662

Bruce Balick

Planetary nebulae like the Dumbbell Nebula, M27, are the shells of gas thrown off of low-mass stars as they die. Supernova remnants, such as the Crab Nebula, M1, develop from the remains of high-mass stars following their explosive deaths.

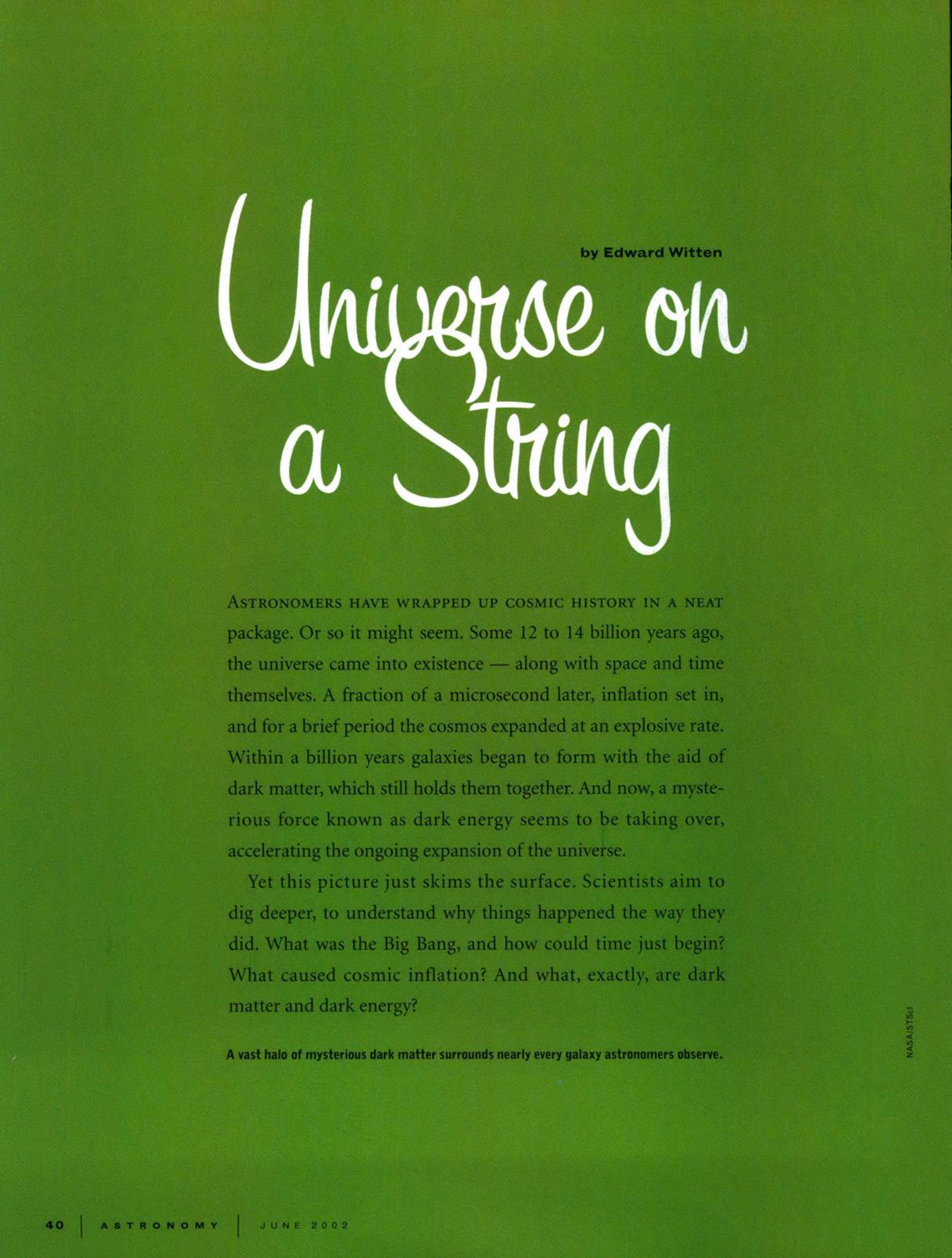
In these pages you will find images of unnamed nebulae. Select a name for one or all and send them to us, or visit the magazine page at Astronomy.com and make your choices at our website. Please include your name and address with your entry. *Astronomy* editors will pick the winning names, which will come with a free one-year subscription to the magazine, a 2003 *Explore the Universe* annual and a 2003 *Astronomy* calendar. The chosen names will likely never become official, but maybe they'll catch on at the next Texas Star Party.

To help us name a nebula, pick one that appears in this article, identify it by its catalog number, and suggest a friendlier name. Enclose your suggestions with your name, address, phone number, and e-mail address if you have one. Please submit your ideas before July 1, 2002. The winning monikers will be announced online and in the October 2002 issue.

Send your suggestions to "Name that Nebula," *Astronomy*, P.O. Box 1612, Waukesha, WI 53187, or visit the magazine page at Astronomy.com. And thanks in advance for your help. — *Bonnie Bilyeu Gordon* ■

Universe on a String

by Edward Witten



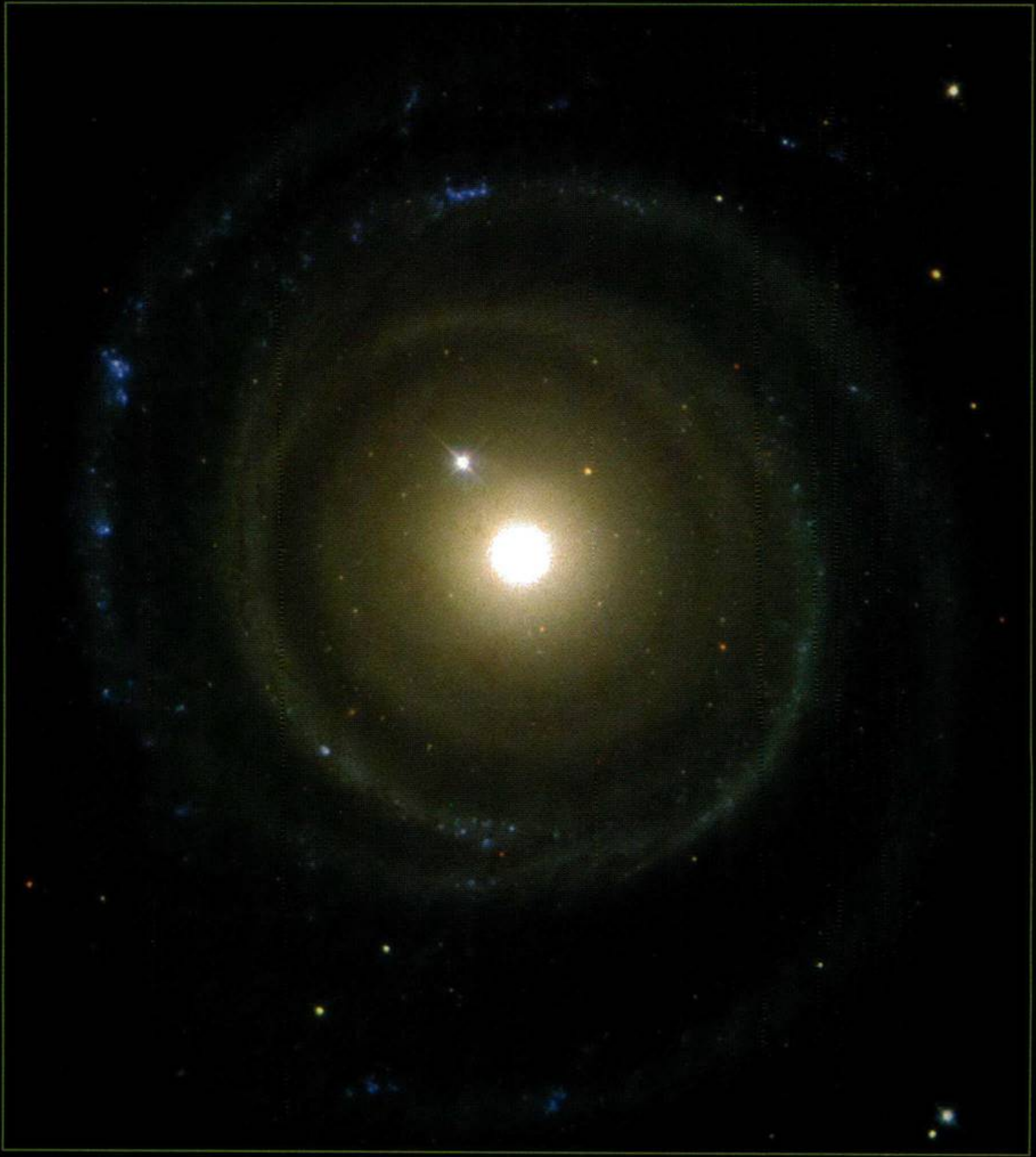
ASTRONOMERS HAVE WRAPPED UP COSMIC HISTORY IN A NEAT package. Or so it might seem. Some 12 to 14 billion years ago, the universe came into existence — along with space and time themselves. A fraction of a microsecond later, inflation set in, and for a brief period the cosmos expanded at an explosive rate. Within a billion years galaxies began to form with the aid of dark matter, which still holds them together. And now, a mysterious force known as dark energy seems to be taking over, accelerating the ongoing expansion of the universe.

Yet this picture just skims the surface. Scientists aim to dig deeper, to understand why things happened the way they did. What was the Big Bang, and how could time just begin? What caused cosmic inflation? And what, exactly, are dark matter and dark energy?

A vast halo of mysterious dark matter surrounds nearly every galaxy astronomers observe.

NASA/STScI

Answers to some of astronomy's most enduring

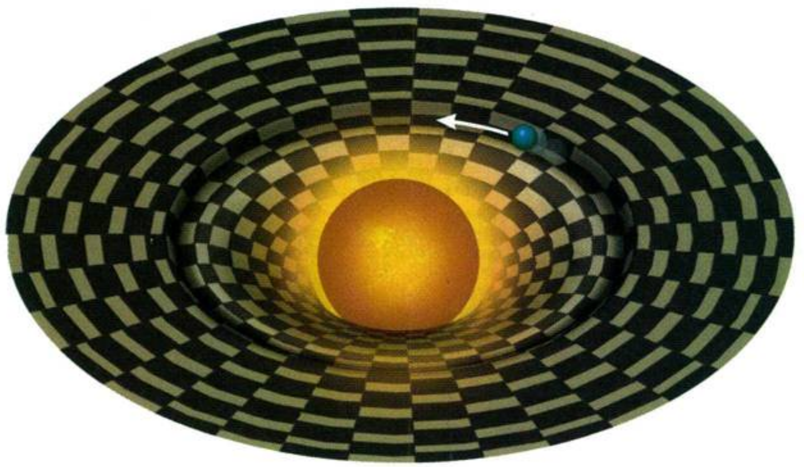


mysteries may be just around the corner.

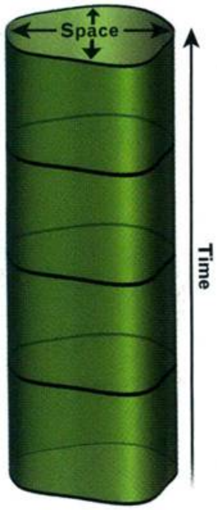
Many scientists believe the answers to these questions are tied up with some of the deepest unsolved problems in physics. A 30-year-old framework known as string theory promises new insights and offers hope that answers to at least some of these puzzles may be on the horizon.

Einstein and Spacetime

The story begins early in the 20th century, when Albert Einstein drastically changed our notions about space and time. His ideas have held up well — almost everything else in our fundamental description of physics has changed since Einstein's day, but we still describe spacetime using the concepts he introduced. Yet many scientists suspect that this is destined to change, and that new developments in the understanding of spacetime will need to emerge before we can attack these grand puzzles.



According to Einstein, gravity arises because massive objects, like the sun, warp spacetime, causing smaller objects like Earth to orbit them.



In string theory, an elementary particle such as an electron or quark is understood as a vibrating string.

All illustrations *Astronomy*: Elisabeth Rowan

Actually, Einstein revolutionized our concepts of space and time two times. The first upheaval came in 1905 with Special Relativity, which explored the strange behavior of matter moving near the speed of light. He showed how clocks carried on a rapidly moving spaceship slow down and the heartbeat of an astronaut almost stands still — as seen by an observer at rest. In Einstein's theory, space and time, which in everyday experience seem completely different, were unified into a strange new concept that came to be called spacetime.

Ten years later, when most scientists had barely recovered from the first shock, the second revolution arrived. In 1915 Einstein completed his greatest and most surprising achievement, the theory of gravity known as General Relativity. According to General Relativity, spacetime is curved, and the curvature is created by matter. When planets travel in elliptical orbits around the sun, for example, they are merely seeking the most direct paths in the curved geometry created by the sun.

Surprising predictions from Special Relativity ranged from an ultimate speed limit — nothing can travel faster than the speed of light — to the famous formula, $E=mc^2$, that describes the equivalence of mass and energy. General Relativity, on the other hand, predicted gravitational waves, black holes, the bending of light by the sun, and the expansion of the universe.

After Einstein, further discoveries changed almost everything else in our understanding of physics. Scientists discovered new building blocks of matter and the surprising laws that govern their behavior. But all the new particles lived and all the new phenomena occurred in the spacetime arena that Einstein had set forth.

In the 1920s, we learned that subatomic particles obey not Newton's laws of motion but the weird and wonderful laws of Quantum Mechanics, in which particles behave as waves and Heisenberg's uncertainty principle gives everything a fuzziness nearly impossible to describe in words. By the mid-1970s, quantum theory was elaborated into a theory of elementary particles — the Standard Model of particle physics — that in its own realm is every bit as successful as Einstein's theory.

By the 1970s, a clear division of labor existed in our understanding of physics. General Relativity describes large objects such as the solar system, galaxies, and the universe. Quantum Mechanics, as elaborated in the Standard Model, describes small objects such as atoms, molecules, and subatomic particles.

Physicists, however, are not satisfied having two different theories that work in two different realms. One reason is simply that big objects are ultimately made out of little objects. The same forces operate on both atoms and stars, for example, even though gravity is more obvious for stars while electricity and magnetism dominate in atoms. So it must be possible to combine the Standard Model and General Relativity into a bigger, more complete theory that describes both atoms and stars.

Moreover, the quest for unification has paid enormous dividends in the past. For example, both the Standard Model and General Relativity were discovered, in large part, by seeking to unify earlier theories. Unfortunately, direct attempts to express General Relativity in quantum mechanical terms have led to a web of contradictions, basically because the nonlinear mathematics Einstein used to describe the curvature of spacetime clashes with the delicate requirements of Quantum Mechanics.

String Theory to the Rescue?

Occasionally, when scientists face a big problem like this one, someone disappears into an attic for seven years and emerges with an answer. That, more or less, is how Andrew Wiles proved Fermat's Last Theorem. In the case of quantum gravity, the "scientist in an attic" approach has never borne much fruit. Instead, by a process of tinkering, physicists who originally had quite a different goal in mind stumbled onto a promising approach.

This came about in the early 1970s with the development of string theory. According to string theory, an elementary particle is not a point but a loop of vibrating string. Just like a violin or piano string, one of these "fundamental strings" has many different harmonics or forms of vibration. For a piano string, the harmonics consist of a basic note — such as middle C — and its higher overtones (one, two, or several octaves higher). The richness of music comes from the interplay of the higher harmonics. Music played with a tuning fork, which produces only the basic note, sounds harsh to the human ear.

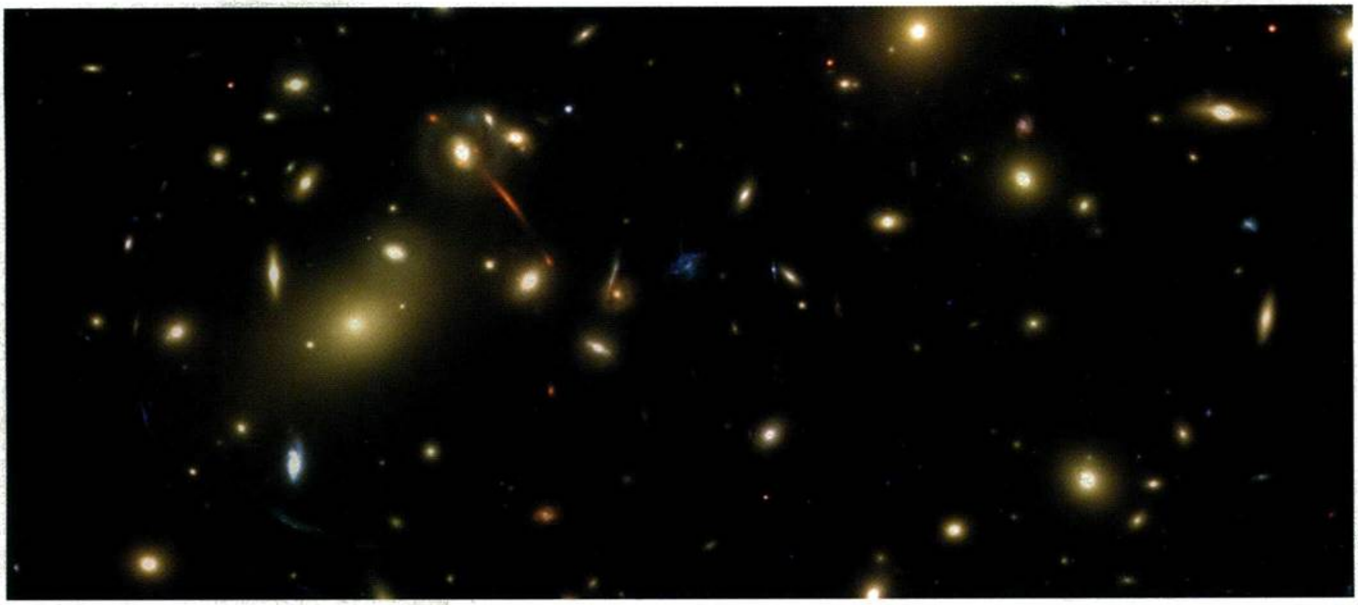
In string theory, the different harmonics correspond to different elementary particles. If string theory proves correct, all elementary particles — electrons, photons, neutrinos, quarks, and the rest — arise as different forms of vibration of the string. Unification of different particles arises because they are different manifestations of the same basic string.

How does this help us with gravity? In the early 1970s, calculations showed that one of the string's vibrational forms had just the right properties to be a graviton, the basic quantum unit of gravity. Like many of the most important discoveries in string theory, this one came from a technical calculation without anyone understanding the big picture in advance.

From little acorns grow mighty oaks. A quantum theory with gravitons must, according to arguments that physicists had known for years, incorporate the full structure of Einstein's theory — at least in circumstances involving astronomical bodies where General Relativity successfully applies. (At the atomic level, such a theory has to depart from Einstein's, which doesn't work quantum mechanically.)

Back in the early 1970s, one of the pioneers of string theory, Italian physicist Daniele Amati, characterized it as "part of 21st-century physics that fell by chance into the 20th century." He meant that string theory had been invented by a lucky chance and developed by a process of tinkering, without physicists really grasping what was behind it. Amati surmised that a true understanding of the foundation of this remarkably rich theory would have to await the 21st century.

Thirty years later, although we understand so many things so much better, there's still much we don't understand at all — including the foundations of string theory. On the other hand, with the 21st century only just begun, we have yet to fall behind Amati's schedule!


NASA/STScI

Distant galaxies appear to be feeling a puzzling force called dark energy that accelerates the universe's expansion.

Fuzziness of Spacetime

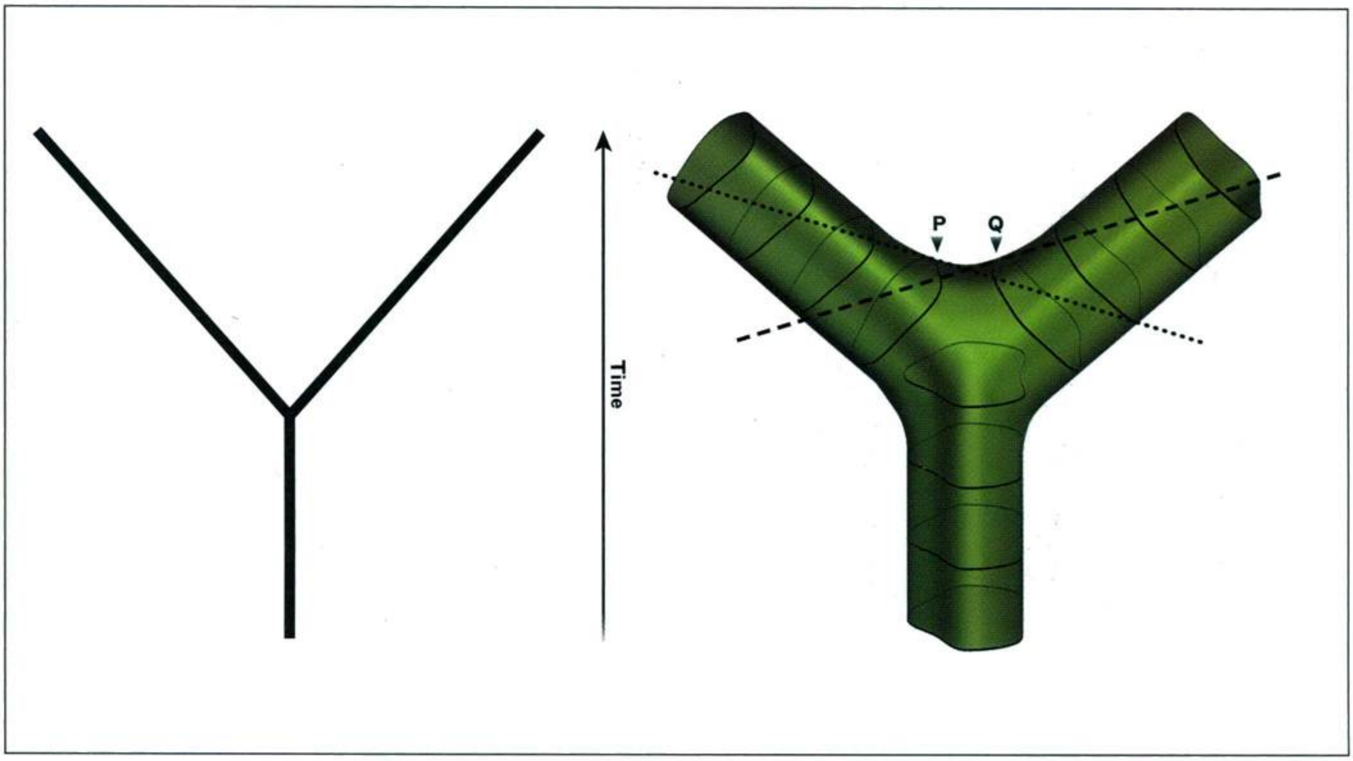
Perhaps the most basic thing we have learned about string theory is that it modifies the concepts of spacetime that Einstein developed. This doesn't come as a complete surprise: Einstein based his theory of gravity on his ideas about spacetime, so any theory that modifies Einstein's gravitational theory to reconcile it with Quantum Mechanics has to incorporate a new concept of spacetime.

String theory actually gives a "fuzziness" to all our familiar notions of space and time, roughly as Heisenberg's uncertainty principle gave a basic fuzziness to classical ideas about the motion of particles. In ordinary Quantum Mechanics, interactions among elementary particles occur at definite points in spacetime. In string theory, things are different: Strings can interact just as particles do, but you cannot say quite when and where this occurred.

Even to a theoretical physicist, this kind of explanation raises more questions than it answers. String theory involves a jump in physical concepts that's large even compared with previous revolutions in physics. There's no telling when humans will succeed in crossing the chasm.

But we really do understand one aspect of how string theory changes the concepts of spacetime. This involves a key part of string theory called supersymmetry. Finding supersymmetry gives us our best hope to prove that the things I have been explaining have something to do with nature and are not just armchair theorizing.

In our everyday life, we measure space and time by numbers. For example, we say, "It is now 3 o'clock," "We are 200 feet above sea level," or "We live at 40 degrees north latitude." This idea of measuring space and time by numbers is one bit of common sense that Einstein preserved. In fact, in his time quantities that could be measured by numbers were all physicists knew about.



When a single elementary particle breaks in two (left), it occurs at a definite moment in spacetime. When a string breaks into two strings (right), different observers will disagree about when and where this occurred. One relativistic observer, who considers the dotted line to be a surface of constant time, believes that the string broke at the spacetime point P while another observer, who considers the dashed line to be a surface of constant time, believes the string broke at Q.

But Quantum Mechanics changed that. Particles were divided into bosons (like light waves) and fermions (like electrons or neutrinos). Quantities like space, time, and electric field that can be measured by numbers are "bosonic." Quantum mechanics also introduced a new kind of "fermionic" variable that cannot be measured by ordinary numbers. Fermionic variables are infinitesimal and inherently quantum mechanical, and as such are hard to visualize.

According to the idea of supersymmetry, in addition to the ordinary, familiar dimensions — the three spatial dimensions plus time — spacetime has additional, infinitesimal or fermionic dimensions. If supersymmetry can be confirmed in nature, this will begin the process of incorporating quantum mechanical ideas in the description of spacetime. But how can we ever know if supersymmetry is right?

Discovering Supersymmetry

In a world based on supersymmetry, when a particle moves in space, it can also vibrate in the new fermionic dimensions. This new kind of vibration gives, for every elementary particle, a cousin or "superpartner," which will have the same electric charge but differ in other properties such as spin. Supersymmetric theories make detailed predictions about how superpartners will behave.

To confirm supersymmetry, scientists would like to produce and study the new supersymmetric particles. The key is to build a particle accelerator with high enough energy.

At present, the highest energy particle accelerator is the Tevatron at Fermilab near Chicago. There protons and antiprotons collide with an energy nearly 2,000 times the rest energy of an individual proton. (The rest energy is given by $E=mc^2$.) A few years ago, this energy made possible the discovery of the top quark, the heaviest known elementary particle. After a shutdown of several years, the Tevatron recently resumed operation with even more intense particle beams.

Around 2006, the available energies will take a big jump when the European Laboratory for Particle Physics, or CERN (located near Geneva, Switzerland), turns on the Large Hadron Collider. The LHC will reach energies of 15,000 times the proton rest energy. The LHC is a multi-billion dollar international project, funded mainly by the European countries with substantial contributions from the United States, Japan, and other countries.

If our hunches prove correct, there's an excellent chance that supersymmetry lies within reach of the LHC, and maybe even of the Tevatron. Many physicists suspect that the LHC will produce supersymmetric particles at a huge rate. If that happens, elementary particle physics will enter a completely new era, with the experimental study of phenomena derived from the quantum structure of spacetime. The next step would be to study the supersymmetric particles in detail, and extract the crucial clues that could help us understand string theory or whatever deeper theory underlies supersymmetry.

The Tevatron and the LHC both accelerate protons — and, in the case of the Tevatron, antiprotons. Proton accelerators give the most practical way to reach the highest possible energy, because protons can be accelerated much more cheaply than other particles.

Unfortunately, they do have a drawback. Typically, proton accelerators produce dozens of uninteresting particles along with the particles of interest. The supersymmetric world is far too complicated to be explored fully at a proton accelerator. For accurate measurements, we need a different kind of machine — one that accelerates electrons and their antiparticles, positrons.

The highest energy electron accelerators built so far are those that have operated at CERN and at the Stanford Linear Accelerator Center in California. These machines have carried out the most precise and complete tests of the Standard Model of particle physics. In the last decade, the United States, Japan, and Germany have devoted intensive research and development toward a higher energy electron accelerator, known as the Linear Collider, that could reach the energy needed to study supersymmetric particles.

Like the LHC, the Linear Collider will be a multi-billion dollar project that can be built only with extensive international cooperation — perhaps encouraged by the curiosity of the public in the countries involved.

The Astronomy Connection

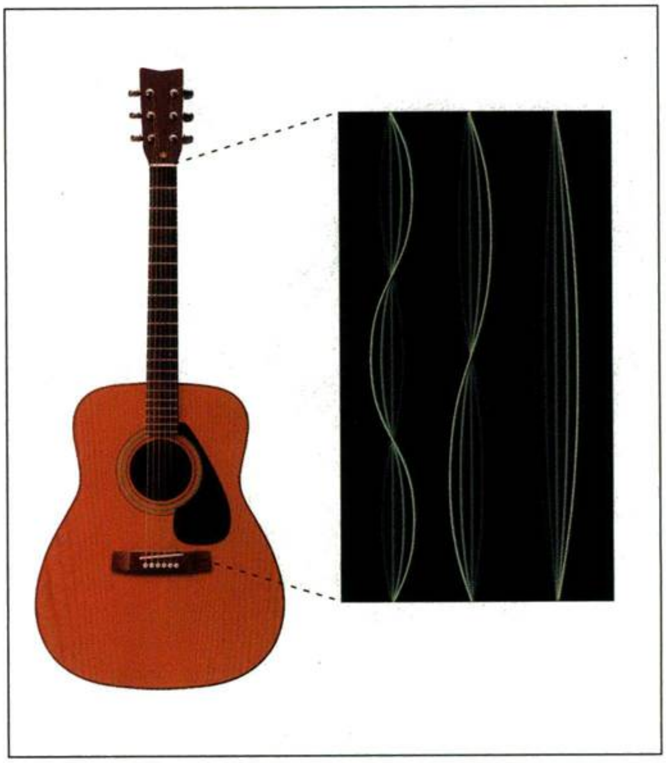
What about those astronomical mysteries we started with? None of the problems yet has any definitive solution, but physicists suspect that they are linked to the exploration of supersymmetry, string theory, and the quantum nature of spacetime.

First, although other possibilities exist, many physicists think the galactic dark matter is a cloud of supersymmetric particles gravitationally bound to the galaxy. Calculations show that such a cloud would have just about the right properties. If this proves to be the right theory, then the dark matter will be detected in the next decade. Special underground detectors can spot the rare interactions of dark matter particles passing through Earth. The detectors lie deep underground, often in mines, to screen them from cosmic rays.

Detecting dark matter would be a milestone in astronomy, but not the whole story. The underground detectors would measure the product of the density of dark matter particles times the interaction rate. To learn how much dark matter of this type exists, scientists would need to separately measure the interaction rate, by producing the dark matter particles in accelerators, and measuring their properties. Thus, the LHC and the Linear Collider, together with supersymmetry, might be key to understanding dark matter.

The dark energy problem appears to be a harder nut to crack. One of the most dramatic discoveries in astronomy and physics in recent years is that the expansion of the universe seems to be accelerating. This points toward a tiny but positive energy density of the vacuum (or possibly a more complicated scenario involving another form of dark energy). The energy of the vacuum is a problem that involves both Quantum Mechanics, since vacuum energy comes from quantum fluctuations, and gravity, since gravity is the only force in nature that "sees" the energy of the vacuum. Because string theory is the only framework we have for understanding quantum gravity, the vacuum energy is a problem for string theorists — not that we've solved it yet.

As for inflation, scientists believe it occurred in the early universe at a temperature far above the energy of particle accelerators and relatively close to the energy at which quantum gravity becomes important. We do not yet have a convincing, detailed model of how and why inflation transpired because the models of particle physics that we have are not adequate at the huge energies of inflation. Understanding inflation requires a much better knowledge of particle physics than we have now, and possibly a full knowledge of string theory and quantum gravity.



A violin, guitar, or piano string can vibrate with many different overtones, or harmonics. They are largely responsible for the richness of music.

Finally, what really was the Big Bang, and how could there have been a beginning of time? This question certainly involves quantum gravity, because Quantum Mechanics and General Relativity were both important near the Big Bang. That makes this another question for the string theorists, even though we do not now seem close to an answer. A plausible guess springs from the way string theory and quantum gravity impart a fuzziness to our concepts of spacetime. Under ordinary conditions, time seems like a well-defined notion, but as you get closer to the Big Bang, quantum mechanical and stringy fuzziness become more significant. The very notion of time seems likely to lose its meaning when one gets back to the beginning — and that, quite likely, will prove to be a key to understanding what the Big Bang really was. ■

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Recent observations have lent tantalizing support to a controversial idea: Earth's fossil fuels were born of dying stars.

Mining for COSMIC COAL

by Sun Kwok

Fossil fuels: They heat our homes, cook our foods, light our streets, and run our transportation. Life without them is unimaginable, even in the face of alternative, non-combustible energy sources. What might be harder to fathom is that these "fossil" fuels may not derive from the decomposition of ancient life on Earth, as scientific consensus has so long held. Instead, they may have come from the exhalations of dying stars, and were eventually packed in the belly of our planet as it formed four and a half billion years ago.

As the name implies, fossil fuels are believed to be products of broken down plant and animal debris deposited in layers near Earth's surface, and transformed through intense heat and pressure over several hundred million years. These fuels come in numerous forms: such as gas (natural gas), liquid (petroleum or crude oil), or solid (coal). They are generally found in sedimentary basins along continental shelves.

The notion that fossil fuels are of biological origin goes back to the late 19th century. And since Earth's flora and fauna only exist near its surface, deposits of oil, gas, and coal — also referred to as hydrocarbons — were expected to be confined to our planet's crust.

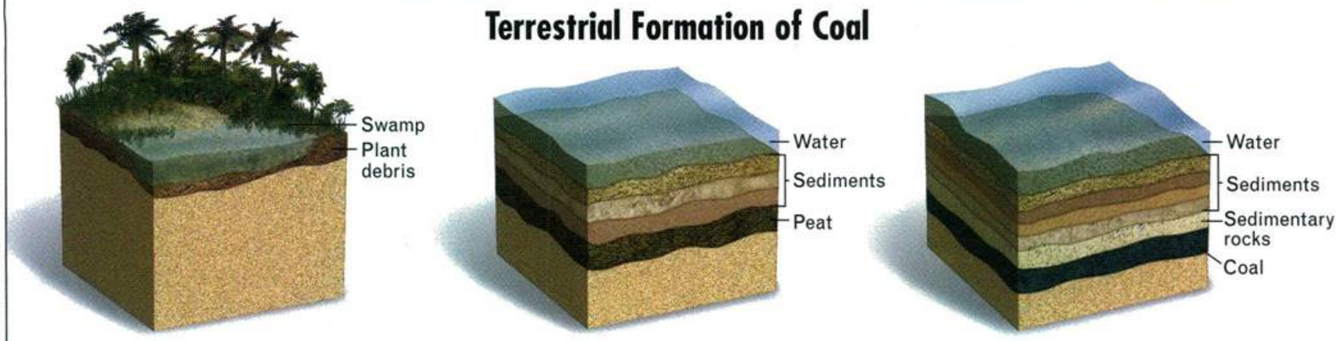
In 1977 Thomas Gold, an astronomy professor at Cornell University, challenged the notion that fossil fuels are born of biological processes. He claimed that our planet's hydrocarbons are extraterrestrial in origin, born in interstellar clouds and carried to Earth by meteoroids and/or comets.

Gold's theory ignited from a discovery in the 1970s that infant Earth was never a molten sphere, as once believed, but was gradually built up from solids — the accretion of dust and rocks in the solar nebula. If hydrocarbons were already present in the pre-solar system mix, he thought, then our developing planet would sweep them up and stow them in its interior. He thought that natural gas, in particular, must now exist at great depths below Earth's crust. These low-weight hydrocarbons would gradually "float" upward toward the planet's surface as plumes of flammable gas or, if trapped inside porous rocks, as wells of oil and gas retrievable by drilling.

If true, Gold's theory may have major ramifications. Our planet's oil and gas reserves will be much, much larger than current estimations. This, in turn, will affect exploration strategies, because these cherished hydrocarbons will not be confined

Growing astronomical evidence has led some scientists to believe that coal and other fossil fuels are of extraterrestrial origin, not from the slow decay of organisms in Earth's crustal layers. Corbis

Terrestrial Formation of Coal



Run-off of rainfall and melted snow carries dead plant material into bodies of water.

Layers of sediment evolve when sand and other materials settle, which then compacts organic material into peat.

Sediment forms an impervious layer called cap rock, which compresses peat and transforms it into coal.

All illustrations/*ASTRONOMY*: Elisabeth Rowan

to sedimentary rocks in the uppermost layers of Earth's crust, but will also bubble in reservoirs a few hundred miles deep.

Old Stars as Molecular Factories

Although no empirical evidence for Gold's hypothesis existed in the late 1970s, recent astronomical observations have injected his theory with a new dose of credence. Old stars nearing the end of their lives manufacture hydrocarbons with a degree of complexity never imagined. These stars then continue to fertilize the galactic environment with the release of large quantities of organic compounds. Because the solar system was created from an interstellar cloud, Earth may well have inherited some of these hydrocarbon-rich materials.

Hydrocarbons, as one might guess, are primarily made up of two elements: hydrogen and carbon. While the Big Bang produced hydrogen in the early moments of the universe, stars are the carbon factories. As a sun-like star ages, it becomes brighter, larger, and redder. Its central core also becomes denser and hotter — so hot, in fact, that helium atoms burn and fuse into carbon. In the last one million years or so of a star's life, these carbon atoms creep to the surface and fill the near stellar atmosphere. Such stars are then labeled carbon stars.

While astronomers have known about the stellar origin of carbon for roughly fifty years, only recently have they realized that these old carbon stars are also capable of turning carbon atoms into molecules. This discovery process began in the early 1970s, when telescopes equipped with high-frequency radio receivers first detected the simple molecule carbon monoxide (CO). Using radio receivers operating at 100 gigahertz (several hundred times higher frequency than commercial television), researchers found an old star called CW Leonis that produces and ejects trillions of tons of carbon monoxide molecules into space every second. We now know that CW Leonis is only one of many thousands of other similar stars "polluting" the Milky Way Galaxy at this very moment.

Among these carbon stars, researchers have detected over fifty molecules, including organic species such as polyacetylene radicals (C_6H, C_8H), cyanopolyynes (like HCN and HC_3N), and sulfuretted chains (C_2S, C_3S). The largest molecule, HC_9N, has an atomic weight of 123, almost twice the molecular weight of the simplest amino acid glycine. Some of these molecules are so alien to traditional chemists that a new scientific discipline called astrochemistry has evolved to study these exotic chemical species.

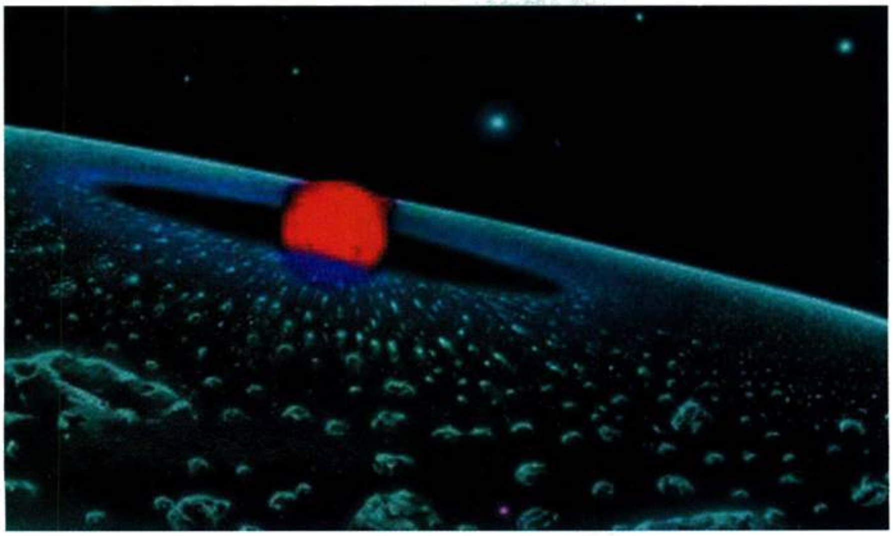
Astronomers have witnessed incredibly high ejection rates of these strange molecules from their parent stars, which can only mean that they are synthesized and replenished on time scales of just a few hundred years. These results are quite surprising. Researchers have come to recognize, however reluctantly, that carbon stars are extremely efficient organic-chemical plants.

Hydrocarbons and Coal from Stellar Chimneys

Further surprises were yet to come. In 1977, three astronomers at the University of California at San Diego, equipped with an infrared telescope on NASA's Kuiper Airborne Observatory, discovered several mysterious chemical-emission features in the planetary nebula NGC 7027, which is known to have descended from a carbon star like CW Leonis. Since these curious infrared features could not be matched with any known terrestrial atoms or

The carbon star CW Leonis has fathered an impressive family of carbonaceous molecules.

Harvard-Smithsonian CfA



molecules, they were dubbed Unidentified Infrared (UIR) features.

These emission features remained unidentified, as astronomers failed to appreciate the possible complexity of the carrier molecules.

Then in 1981, Walt Duley, a professor of physics at York University (now at the University of Waterloo) and David Williams of the University of Manchester (now at University College–London) suggested that the UIR features represent aromatic compounds. Aromatic compounds are molecules with ring-like structures — benzene and toluene are the most common everyday examples. (Benzene is the simplest aromatic hydrocarbon and serves as a building block for more complex polycyclic aromatic hydrocarbons, or PAHs, which are commonly used in drugs, dyes, plastics, and pesticides.) Researchers were skeptical at first because most of them found it hard to believe that such complex organic molecules could exist in deep space. After twenty years and many more observations, they have finally come to accept the aromatic origin of the UIR features, but are as yet unsure about the exact form of the aromatic compound found in these planetary nebulae. All we do know is that these mystery molecules contain a hundred or more hydrogen and carbon atoms.

Since we haven't seen these aromatic compounds in carbon stars, detecting them at a later stage of evolution — in planetary nebulae — implies that these compounds are born in the diffuse clouds surrounding the stars. In looking at theories of stellar evolution, most imply that only a few thousand years separate the stages of a carbon star and planetary nebulae. Hence, these aromatic compounds must have been transformed from simpler molecular forms over a similar, astronomically brief, timescale.

To further pinpoint the chemical process, it would be useful to study the transitional objects between carbon stars and their successive planetary nebulae. These objects, called proto-planetary nebulae, evolve rapidly and exist a mere one thousand years. Because of their rapid evolution, they are extremely rare and difficult to catch. Beginning in the early 1980s, I became interested in searching for these elusive creatures. Now, after 15 years, we have discovered approximately thirty proto-planetary nebulae.

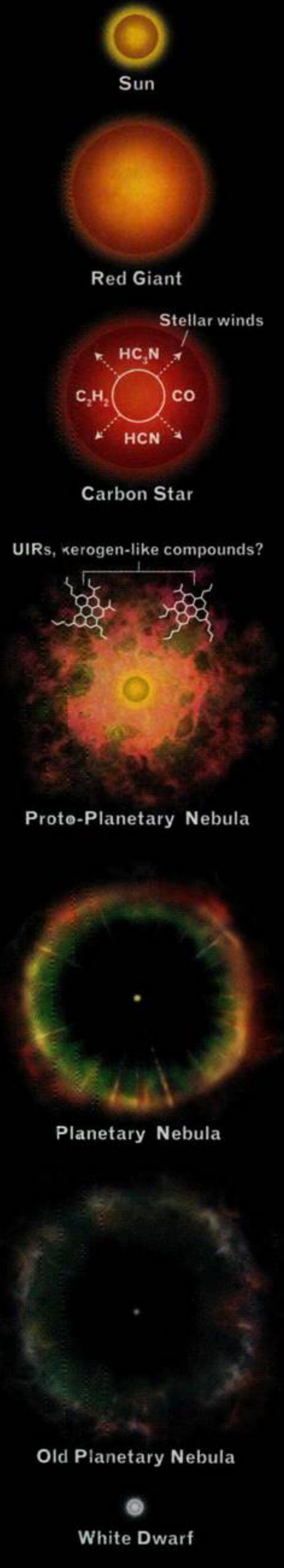
In 1995, the European Space Agency launched a satellite called the Infrared Space Observatory (ISO), which has capabilities that are well suited for hunting down and identifying these curious chemical processes inside proto-planetary nebulae. By observing a number of these nebulae, astronomers have discovered that they reveal a much richer spectrum than expected, showing signatures of so-called aliphatic chains attached to aromatic rings (aliphatic chains are commonly found in fats and hydrocarbons). It is now theorized that when these substances formed, they were made in a disorganized manner with a mixture of chemical structures. But with a little time accompanied by intense ultraviolet radiation from the parent star, these molecules soon shed part of their outer structures and become aromatic in nature.

A group of scientists led by Renaud Papoular of the Atomic Energy of France has taken great interest in these observations. They compared their infrared observations with those of coal and found amazing similarities. Coal is composed of a mixture of aromatic rings and aliphatic chains, and its black color also correlates well with our findings. Papoular's team is particularly interested in relating some astronomical results to kerogens — insoluble, tar-like, organic compounds distributed in rocks — which are thought to be the likely source of fluid hydrocarbons such as oil.

These suggestions first seemed totally incredible. Scientists have long thought coal was only created under extremely high pressure inside Earth, a far cry from the low-pressure environments found in space. Moreover, astronomers found it aesthetically unappealing that a dirty, black substance could spawn from otherwise brilliant heavenly bodies.

However, the spectral resemblance between laboratory and astronomical measurements is so strong, we now believe that even if the mystery substance we observe is not coal, it must be something shockingly similar. For example, Duley has blasted graphite with lasers and created a synthetic material called hydrogenated amorphous carbon (HAC), which also

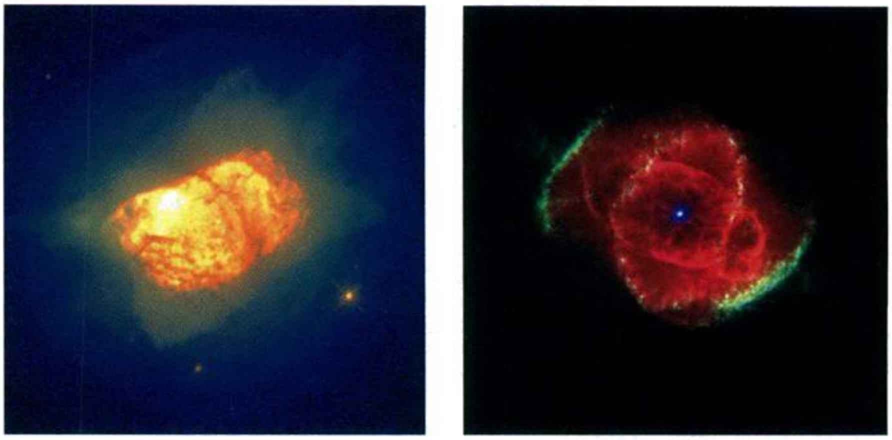
A Stellar Refinery?



The eons-long evolution of a sun-like star through succesive stages thought to produce and distribute some of the universe's more complex carbon-based chemical species.

shows some similarity to our observed features. HAC is different from coal in that it contains fewer impurities such as oxygen and nitrogen, but the chemical structures of the two are an extremely close match. At about the same time a team of Japanese researchers synthesized another artificial coal-like substance called quenched carbonaceous composite (QCC)in the laboratory. Remarkably, QCC also shows some of the rich aromatic/aliphatic features seen in the infrared spectra of numerous protoplanetary nebulae.

These dying stars are churning out organic matter with a high degree of complexity; whether the substance is coal, HAC, or QCC, it is too early to tell. But it looks like the creation of complex organic molecules is no longer the sole domain of Earth.



Hubble captured these images of planetary nebulae NGC 7027 (left) and the Cat's Eye Nebula,NGC 6543, (right), which may hold among their splendor coal-like substances. NASA/STScI.

An Infinite Supply of Oil?

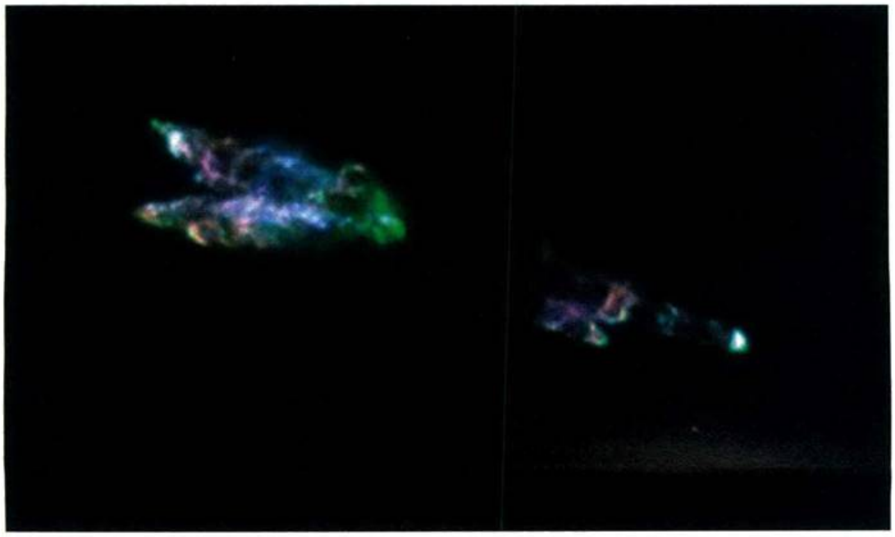
The geological community still gives Thomas Gold's theory of the abiogenic origin of fossil fuels little, if any, weight. One of its objections is that primordial hydrocarbons are unlikely to survive the high temperature and shock generated in the process of accretion during Earth's formation. In Gold's original "deep-Earth gas theory," he only considered simple hydrocarbons as primordial gas. At that time, of course, he didn't know that stars can manufacture organic matter as complex as kerogen. Solids like kerogen are certainly more resilient than any gas, and have a much greater chance of surviving the violent physical forces involved with our planet's birth.

To explain the existence of coal, Gold hypothesized that microorganisms deep inside Earth may play a role in converting hydrocarbons into coal through so-called hydrogen extraction. But if kerogen is indeed an early earthly stowaway, then this hypothesis is unnecessary. Coal evolves from kerogen through the natural loss of hydrogen, oxygen and nitrogen. Petroleum is often found in sedimentary rocks rich in kerogen and is believed to simply degrade from kerogen over time. Both processes are accompanied by a release of natural gas.

Is there enough celestial organic matter to account for Earth's known reserves of coal, oil, and gas? We know that complex hydrocarbons are routinely produced by stars and ejected in large quantities out into interstellar space. Our best estimate is that carbon stars pump out the equivalent of the mass of the sun (300,000 Earth-masses) in the Milky Way Galaxy every year. Even if a small fraction of these hydrocarbons is in the form of organic matter such as kerogen or HAC, over the several-billion-year lifetime of the galaxy, well, that's a substantial amount (over a trillion Earth-masses). The solar nebula, from which our solar system was formed, was likely to have contained remnants (possibly on the order of 1,000 Earth-masses) of these organic compounds. Whether these compounds survived Earth's birth pangs and stayed intact deep inside the planet remains uncertain. But we also have to remember that although our planet seems immense to us, it is but a speck of dust on the galactic scale. Since the total amount of carbon contained in kerogen, coal, oil and gas in our planet's crust is about 1 millionth (10^{-6}) of Earth's mass, even a small amount of extraterrestrial organic matter could easily overwhelm our known fossil-fuel deposits.

As remote as these possibilities are, we cannot help but ponder their implications. The belief that there may be a finite supply of fossil fuels plays a significant role on the world stage. Diplomatic alliances are made and wars are fought in order to secure energy supplies. Given the important consequences, how can we afford not to look further into this question?

Proto-planetary nebulae like CRL 618 just might be the universal birthplace of complex organic molecules. NASA/STScI



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*Dr. Sun Kwok is a professor of astronomy at the University of Calgary and a Killam Fellow of the Canada Council for the Arts. He is the author of two recent books (*The Origin and Evolution of Planetary Nebulae,* 2000;* Cosmic Butterflies, *2001) published by the Cambridge University Press.*

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sky Show

june

A pair of evening stars and a solar eclipse outshine a fading comet.

by Martin Ratcliffe and Alister Ling

At the climax of a three-month planetary exhibition, Venus and Jupiter shine together in the evening sky as the display of orange and red colors deepens into the night.

Brilliant Venus is without doubt the crown jewel of this month's sky. Jupiter, now floating only half a binocular field to Venus's left, seems to have lost its luster after ruling the winter. The pair closes in nicely until the evening of June 3, then separates as Jupiter sinks into the glow of the sunset. If you see a faint twinkling to the upper left of Jupiter, that's Delta (δ) Geminorum, the same star that adorned the total solar eclipse of July 11, 1991. Delta Gem slumps past Jupiter on June 9, where it sits a moon's width to the left of the planet.

A dramatic "ring of fire" sunset eclipse takes place on June 10, just south of Puerto Vallarta in Mexico. Across the U.S. and Canada a partial eclipse graces the late afternoon skies, but observers on the eastern seaboard will miss the action since it happens after sunset. Northeastward from Texas up through Lake Huron lucky skygazers get maximum eclipse right at sunset. (Warning: When observing solar phenomena you must use proper eye protection at all times.)

Summer thunderheads chase Venus and the Hyades in the early morning sky. Chris Johnson

A partial solar eclipse caps off an already majestic sunset. Alister Ling

A spectacular crescent moon passes Venus on June 13. Western Europeans can witness the close approach itself, while North Americans will see the moon climb up and away from Venus with each passing hour.

Yet another photo opportunity comes on June 20, when Venus skims the northern flank of the Beehive Cluster, M44. Using a telephoto lens and a "star" diffraction filter should produce a delightful image.

The summer solstice occurs on June 21 at 9:24 A.M. EDT, marking the longest day of the year for the Northern Hemisphere. Sharp-eyed citizens may note that the earliest sunrise and latest sunset do not occur on this day. The two events are offset slightly from the solstice, which many people think is a consequence of Earth's elliptical orbit. Jean Meeus, in his book *Mathematical Astronomy Morsels*, demonstrates that while orbital eccentricity does play a role, the primary factor is Earth's tilt. How this works is not easily explained. But Meeus does a great job clarifying this and many other solar system effects, without relying on too much math, as one might be led to believe by looking at the book's title.

For Southern Hemisphere observers, Mercury climbs out of the morning twilight paired with Saturn; both planets are equally bright. Those of you living north of the equator who want to glimpse this planetary pair had better set your alarm clocks — you'll need to awaken around 4 A.M. to see them before sunrise.

If predictions worked out for April, you will have had a chance to see comet Ikeya-Zhang with the unaided eye from a dark country site. As it recedes from us like a pop fly ball over a fence, it's time to set aside the binoculars and watch it through a scope.

It's especially fun to follow an asteroid or comet when its path takes it close to a deep-sky object. Asteroid 6 Hebe begins the month of June near an orange star, V Aquilae, and then drifts near the Wild Duck Cluster, M11. Comet WM1 LINEAR sails close to the Hercules Cluster, M13.

June 2002

1 The moon passes 4° south of Uranus, 2 P.M. EDT

2 Last quarter moon is at 8:05 P.M. EDT

3 Venus passes 1.6° north of Jupiter, 2 P.M. EDT

4 The moon is at apogee (251,358 miles from Earth), 8:57 A.M. EDT

7 Pluto is at opposition, 1 A.M. EDT

9 Saturn is in conjunction with the sun, 7 A.M. EDT
The moon passes 3° north of Mercury, 10 A.M. EDT
Venus passes 5° south of Pollux, 4 P.M. EDT

10 New moon is at 7:46 P.M. EDT; annular solar eclipse

12 The moon passes 0.9° north of Mars, 8 A.M. EDT
The moon passes 2° north of Jupiter, midnight EDT

13 The moon passes 1.5° north of Venus, 5 P.M. EDT

17 First quarter moon is at 8:29 P.M. EDT

19 The moon is at perigee (229,478 miles from Earth), 3:30 A.M. EDT

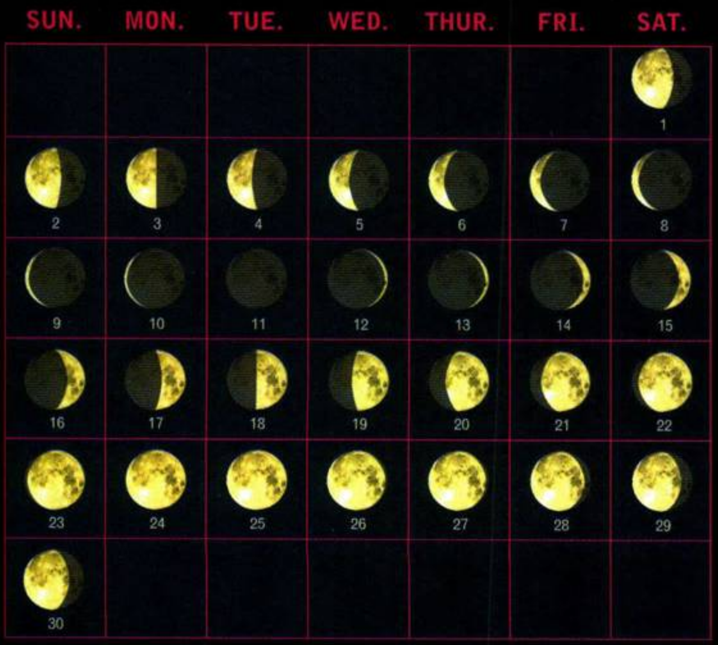
21 Summer solstice is at 9:24 A.M. EDT
Mercury is at greatest western elongation (23°), 11 A.M. EDT

23 Mercury passes 2° north of Aldebaran, midnight EDT

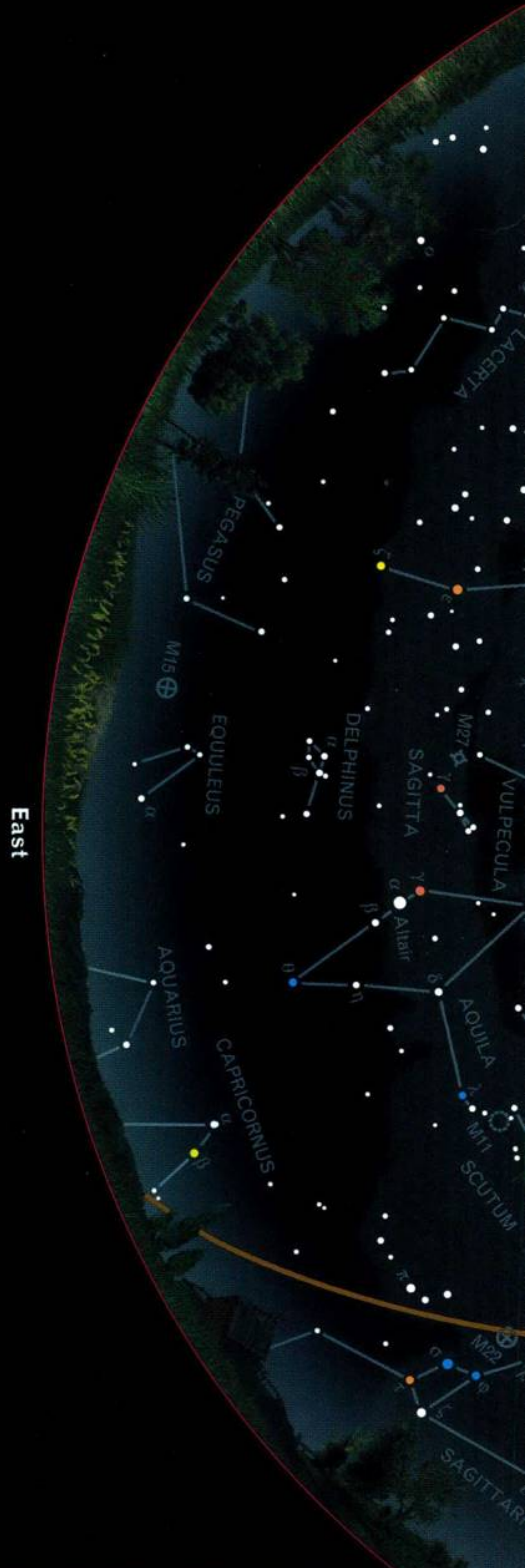
24 Full moon is at 5:42 P.M. EDT; penumbral lunar eclipse

27 The moon passes 4° south of Neptune, noon EDT

28 The moon passes 4° south of Uranus, 10 P.M. EDT

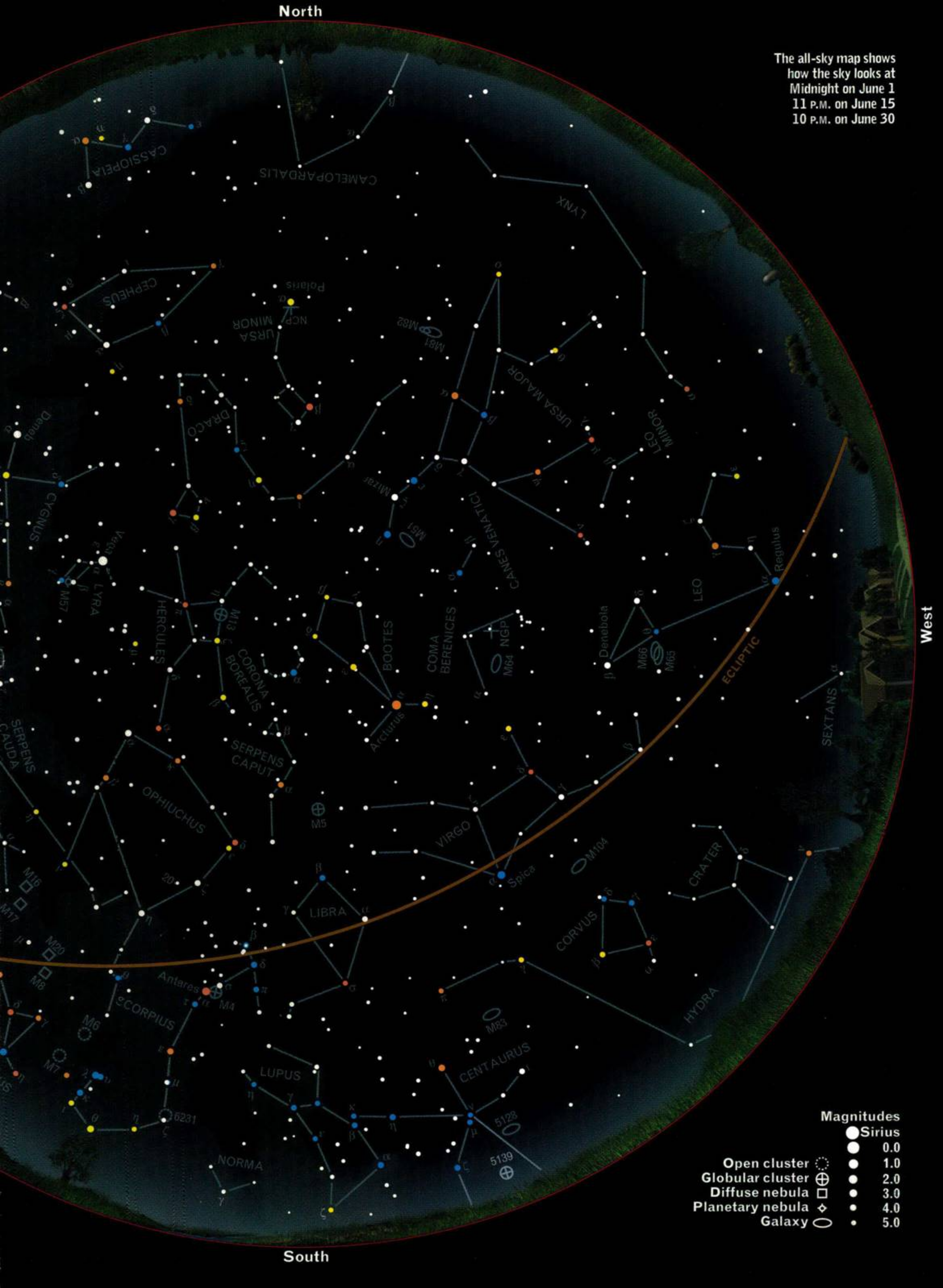


SUN.	MON.	TUE.	WED.	THUR.	FRI.	SAT.
						1
2	3	4	5	6	7	8
9	10	11	12	13	14	15
16	17	18	19	20	21	22
23	24	25	26	27	28	29
30						



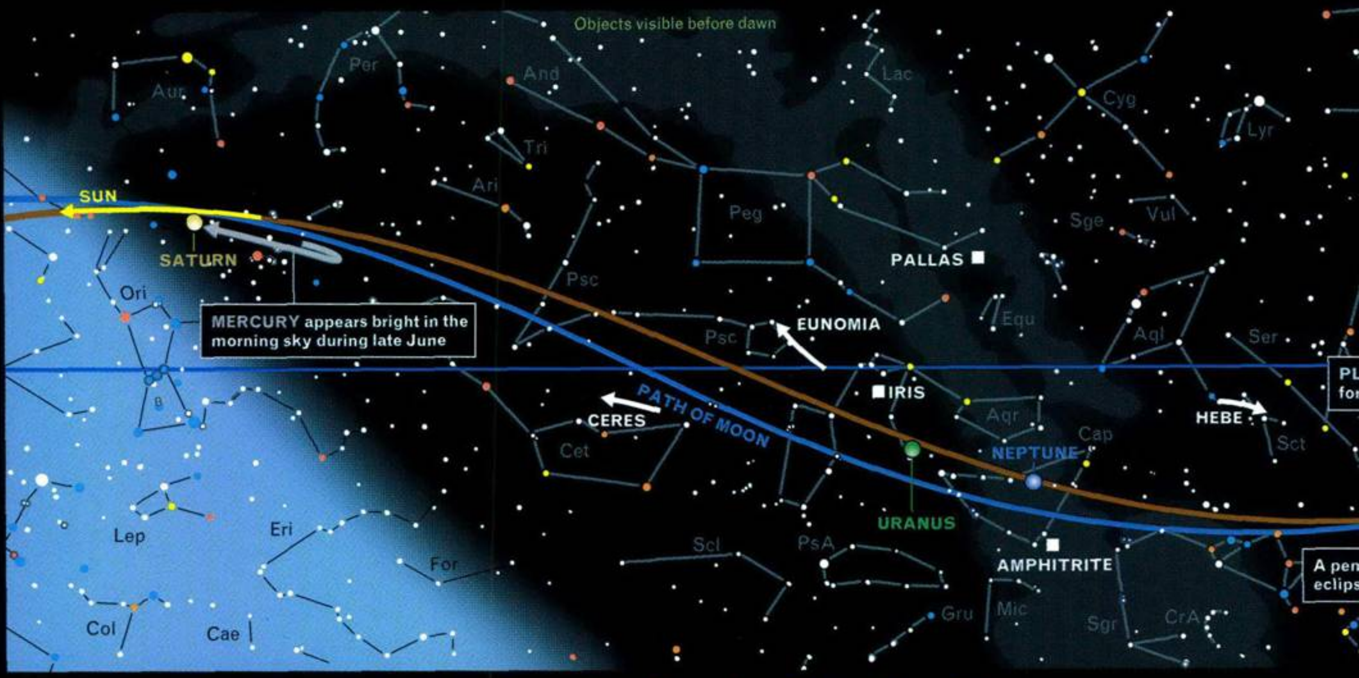
This map portrays the sky at times shown in the upper right corner of the page. Located just outside the map are the four directions: north, south, east, and west. To find stars above your horizon, hold the map overhead and orient it so a direction label matches the direction you're facing. The stars above the map's horizon now match what's in the sky.

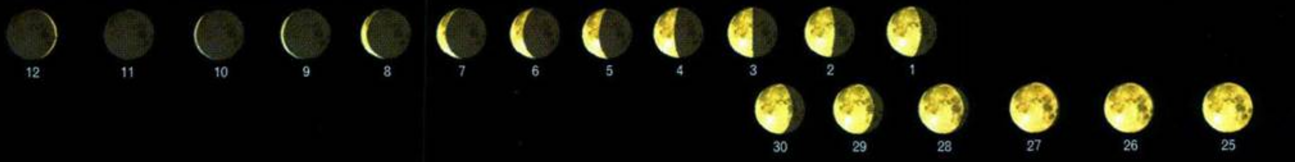
The all-sky map shows
how the sky looks at
Midnight on June 1
11 P.M. on June 15
10 P.M. on June 30


North
CASSIOPEIA
CAMELOPARDALIS
LYNX
CEPHEUS
Polaris
NCP
URSA MINOR
M81
M82
DRACO
URSA MAJOR
LEO MINOR
Deneb
CYGNUS
Mizar
M51
CANES VENATICI
Vega
LYRA
M57
HERCULES
M13
BOOTES
COMA BERENICES
NGP
M64
LEO
Regulus
Denebola
M66
M65
ECLIPTIC
West
CORONA BOREALIS
Arcturus
SEXTANS
SERPENS CAUDA
SERPENS CAPUT
OPHIUCHUS
M5
VIRGO
M104
CRATER
Spica
M16
M17
LIBRA
CORVUS
M20
M8
Antares
M4
SCORPIUS
M6
M7
HYDRA
M83
CENTAURUS
LUPUS
6231
NORMA
5128
5139
South
Magnitudes
Sirius
0.0
1.0
2.0
3.0
4.0
5.0
Open cluster
Globular cluster
Diffuse nebula
Planetary nebula
Galaxy

Path of the Planets

This map unfolds the entire night sky from evening (at right) until sunrise (at left). Arrows and squares show the movements and locations of solar system objec


Objects visible before dawn
Aur
Per
And
Tri
Ari
Lac
Cyg
Lyr
SUN
SATURN
Ori
Peg
Psc
PALLAS
Sge
Vul
Equ
Aql
Ser
Psc
EUNOMIA
MERCURY appears bright in the morning sky during late June
IRIS
CERES
PATH OF MOON
Cet
Aqr
Cap
NEPTUNE
HEBE
Sct
PL
for
Lep
Eri
Scl
PsA
URANUS
AMPHITRITE
A pen
eclips
For
Col
Cae
Gru
Mic
Sgr
CrA


12
11
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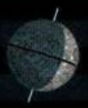
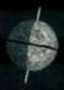
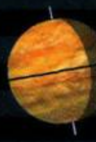
7
6
5
4
3
2
1
30
29
28
27
26
25

PLANETS	MERCURY	MERCURY	VENUS	MAR
Date	June 15	June 30	June 15	June
Magnitude	1.3	−0.3	−4.0	1.7
Angular Size	9.5"	6.7"	13.8"	3.7"
Illumination	23%	57%	77%	99%
Distance (AU) from Earth	0.710	1.005	1.208	2.55
Distance (AU) from Sun	0.438	0.360	0.720	1.62
Right Ascension (2000.0)	4h06.5m	5h06.9m	8h11.2m	6h50.
Declination (2000.0)	16°44'	20°53'	22°03'	23°5

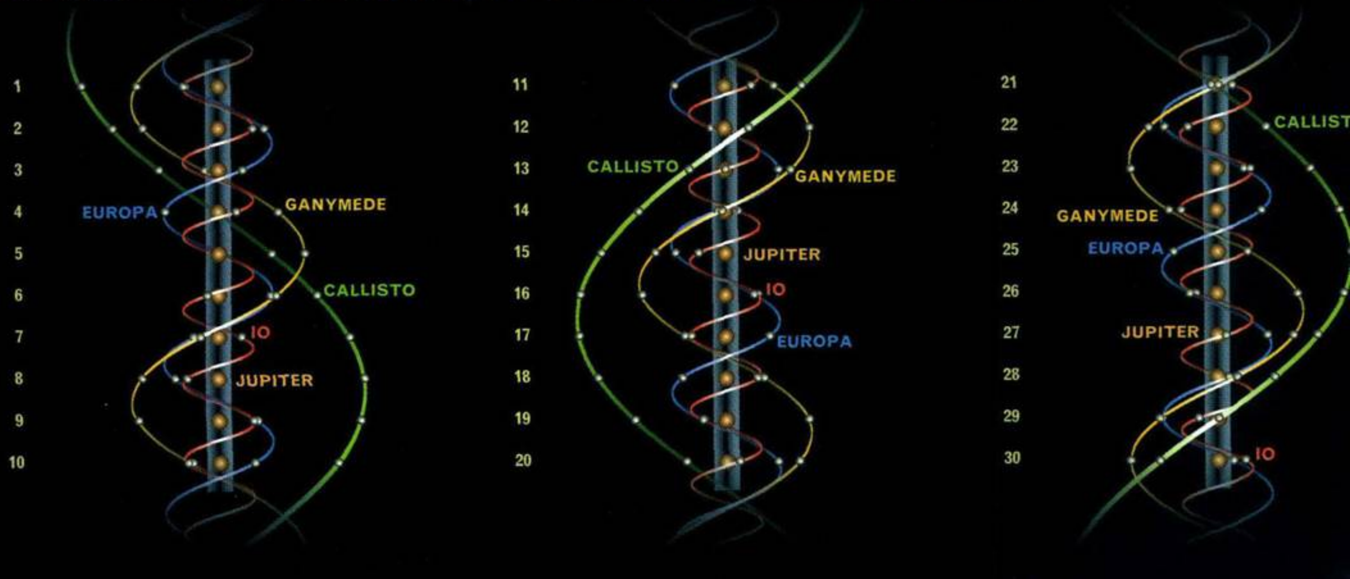




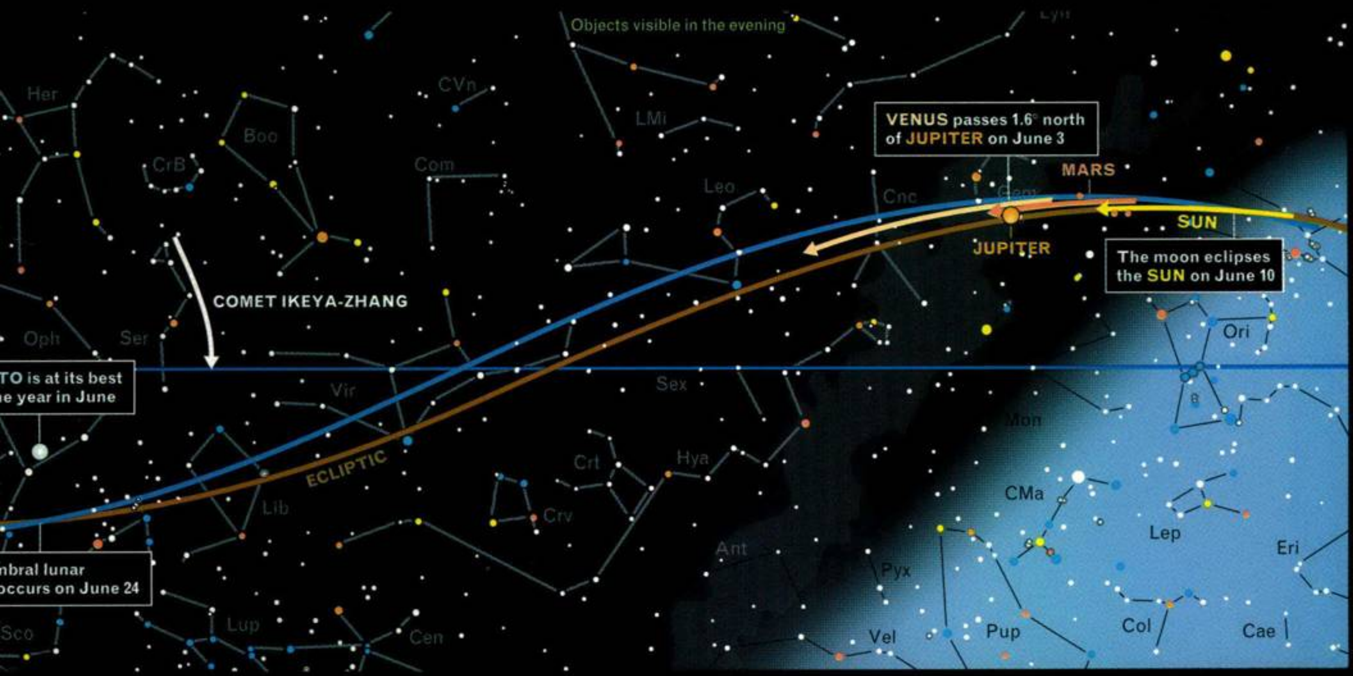


Jupiter's Moons

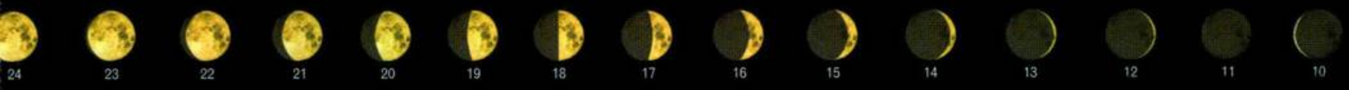
Dots display positions of Galilean satellites at 11 P.M. EDT on date shown. South is at top to match the view in a telescope.



during the month.


Objects visible in the evening
Lyn
Her
CVn
Boo
CrB
Com
LMi
Leo
Cnc
Gem
VENUS passes 1.6° north of JUPITER on June 3
MARS
SUN
JUPITER
The moon eclipses the SUN on June 10
COMET IKEYA-ZHANG
Oph
Ser
TO is at its best
e year in June
Vir
Sex
Ori
Mon
ECLIPTIC
Crt
Hya
Lib
CMa
Lep
Eri
Crv
Ant
Pyx
nbral lunar
occurs on June 24
Sco
Lup
Cen
Vel
Pup
Col
Cae

To locate the moon in the sky, draw a line from the phase shown for the day straight up to the curved light-blue line.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11
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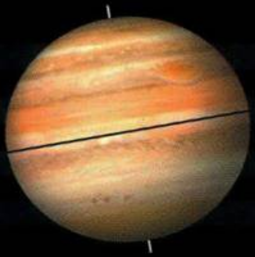
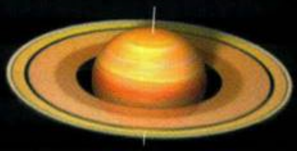
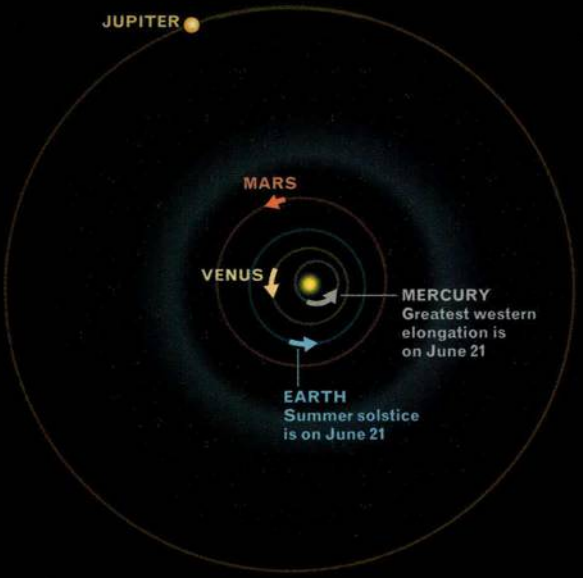


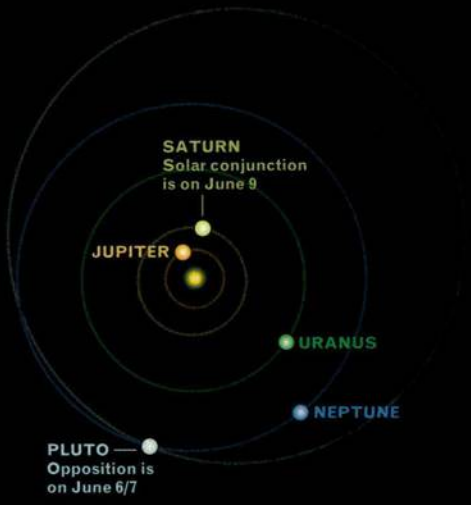


JUPITER	SATURN	URANUS	NEPTUNE	PLUTO
June 15	June 30	June 15	June 15	June 15
–1.8	0.1	5.8	7.9	13.8
32.2"	16.6"	3.6"	2.3"	0.1"
100%	100%	100%	100%	100%
6.128	10.013	19.551	29.388	29.409
5.232	9.046	20.000	30.091	30.392
7h24.4m	5h21.5m	22h04.6m	20h52.4m	16h54.2m
22°17'	21°52'	–12°37'	–17°29'	–11°48'

The Planets in Their Orbits

Arrows and dots show planets' positions during the month.


JUPITER
MARS
VENUS
MERCURY
Greatest western elongation is on June 21
EARTH
Summer solstice is on June 21


SATURN
Solar conjunction is on June 9
JUPITER
URANUS
NEPTUNE
PLUTO
Opposition is on June 6/7

Comet LINEAR hides in Hercules

The first thing most observers associate with Hercules is M13, the Hercules Cluster, and with good reason: It's the best globular in the northern sky, easily seen through even a city's veil of light pollution. Tucked away far behind this clump of stars lie dozens of galaxies. With patience, you can root out a "bad apple," the masquerading comet LINEAR WM1. Before the hunt for this comet, let's become a little more familiar with M13.

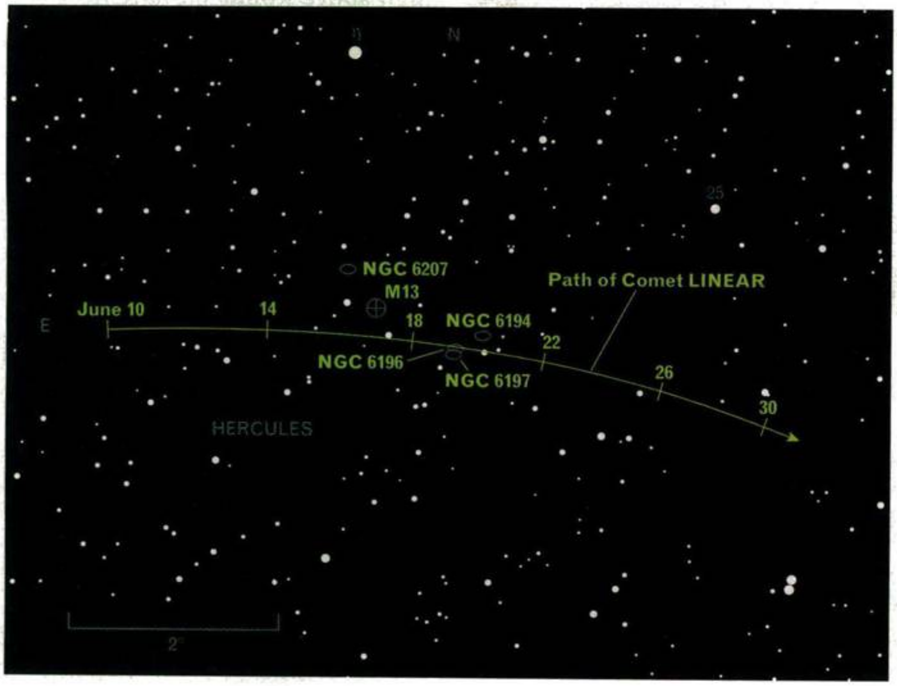
Discovered in 1714 by Edmond Halley of comet fame, this huge ball of stars is one of the Milky Way Galaxy's older members. Despite its impressive distance of some 24,000 light-years, it's bright enough to see with the unaided eye from a modestly dark site. Once you've fixed your gaze on it, a million or so stars will tickle your retina.

With binoculars, you'll see two stars that frame M13's circular gray fuzz. Try leaning against a wall or propping your elbows on the roof of a car to steady the view. Only the most exquisite 90mm (3.5-inch) scopes will capture what M13 is really made of. By the time you hit 5 inches or more of aperture, you'll begin to see so many stars in the cluster that they'll be difficult to count.

The Great Cluster in Hercules, M13. Leo Henzl

Real or imagined? Back in the late 1800s, Lord Rosse discovered three slightly dark lanes intersecting like a propeller on M13's face. Many observers saw them, but long-exposure photographs showed no evidence of them. They were considered a result of our brain's wiring, until the 1980s when amateurs began to see these lanes anew in their big telescopes. The book is still open whether these are real dust lanes or just random clumping.

With my 4.7-inch refractor pumped up to 213x, I found my eye pulled toward the southeastern side of M13. This is where the lanes are, not in the middle where most people look. For those of you without a drive, east is the side that leaves the field of view last. At lower magnifications the "propeller" is much more difficult to notice.



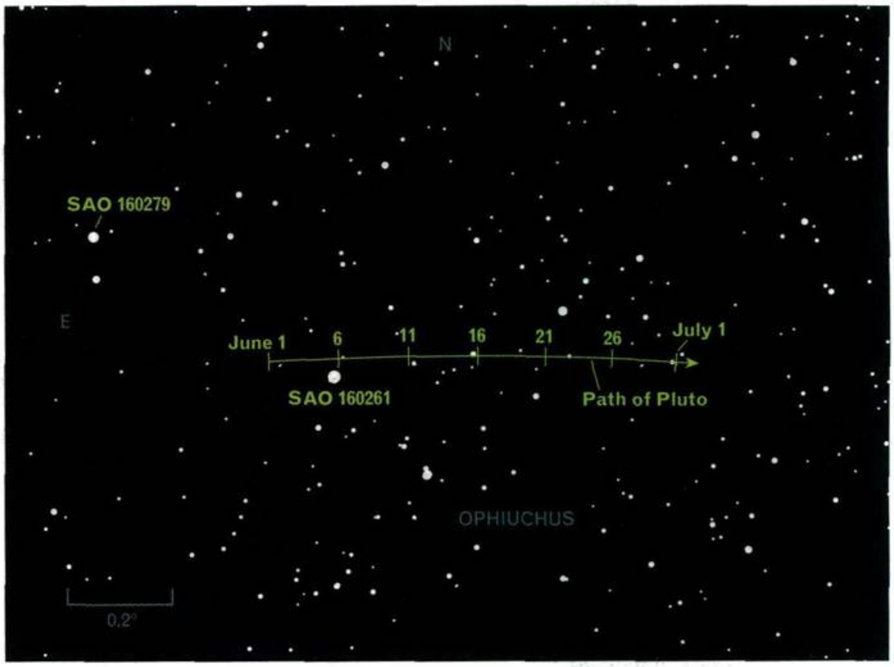
M13 provides a sparkling backdrop to fading comet LINEAR WM1's fly-by on the evening of June 17. Look about one cluster-width to the south. If you can, compare the comet's brightness to galaxy NGC 6207, a little farther to the north of the great globular.

Another interesting encounter will occur June 19, as the comet slowly drifts toward a clump of galaxies whose brightest member is NGC 6196, at magnitude 12.9. Barely 5' south is the fuzzy spot of NGC 6197, which will be a challenge for a 10-inch scope. Within slightly easier reach is NGC 6194, glowing feebly at magnitude 13.8. The Japanese and other Eastern Hemisphere observers are best positioned to capture CCD images of the comet in the middle of the galaxy clumping on the night of June 20.

There are many other galaxies to find in the constellation Hercules. NGC 6207, which is close to M13, is one of the brightest. Tiny IC 4617 is a challenging object for a 12.5-inch scope. The new *Uranometria 2000.0* is a wonderful guide for those heading to the deep end of the galactic pool.

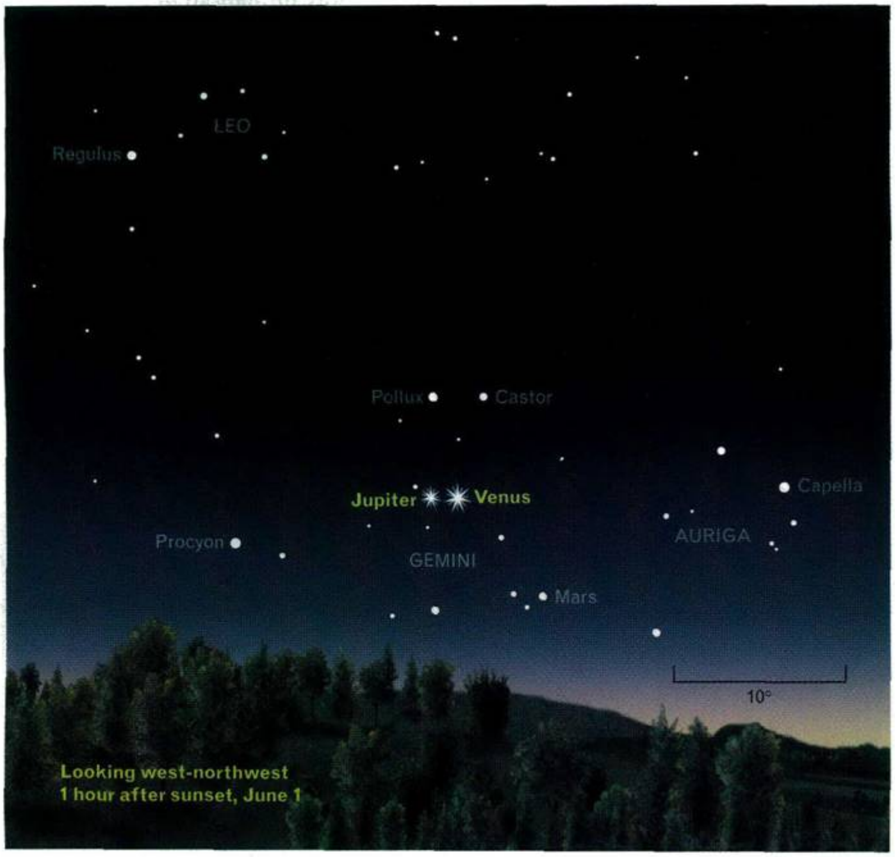
sky Show

Following a veritable observing feast with five planets visible in the evening skies during May, the month of June marks the transition to a more sedentary, yet nonetheless dazzling, pace involving the two brightest planets — Jupiter and Venus. In contrast, Pluto, the dimmest planet, reaches opposition this month. On June 11 a partial eclipse of the sun occurs, which should be visible from most of the United States.



The brightest planet in the western sky after sunset is **Venus**. During May, Venus's nightly path carried it close to Saturn and Mars. But now **Saturn** is lost in the sun's twilight glow, while Mars glows dimly at magnitude 1.7 in the western reaches of Gemini. This leaves Venus and Jupiter sparkling in the night sky. And sparkle they do. **Jupiter** shines at a usually majestic magnitude –1.9, no match for Venus blazing at magnitude –3.9. Both planets set less than two hours after sunset.

The two bright planets stand 2.4° apart on June 1, mirroring the orientation of Castor and Pollux, the two brightest stars in Gemini the Twins, which stand directly above them. Just three days later Venus has moved to stand above Jupiter, where their separation shrinks to less than 2°. June 3 marks their conjunction, at which point the planets are apparently closest to each other — just 1.6° apart.



**Looking west-northwest
1 hour after sunset, June 1**

Seen from Earth, this seemingly tight pairing is, of course, illusory. A simple view of our solar system from high above would show Venus lying inside Earth's orbit, while Jupiter lies far across the solar system. The only reason they appear close together in the sky is due to the line of sight from our earthly vantage point. Consider the two planets' distances from Earth: Venus is fairly close at a distance of 121 million miles (195 million km), but Jupiter is nearly five times as far away at a distance of 559 million miles (899 million km).

Now if both planets were the same size, Jupiter would appear five times smaller as seen from Earth. Yet check out their apparent angular diameter. Venus spans 13" (three-thousandths of a degree), while Jupiter's apparent diameter is 32" (almost nine-thousandths of a degree), nearly three times larger. Just this simple observation shows how much bigger Jupiter is compared to our neighboring planet Venus.

Through telescopes, even the sim-

Above, left: Jupiter's Red Spot appears here in a rather bland cream color. Jim Baumgardt

Above, right: Here the Red Spot appears as a rusty orange. Klaus Brasch

plest store-purchased variety, Venus and Jupiter exhibit some interesting features. As Venus rounds the sun it shows a phase rather like the moon. During June the illumiated portion of its disk shrinks from 80 to 72 percent. You can follow the shrinking phase throughout the summer. You'll notice that as the phase shrinks, the apparent size of Venus will grow as it approaches closer to Earth.

Jupiter appears slightly flattened at its poles compared to its equatorial girth. Its speedy rotation period of 9 hours 50 minutes at the equator is too much for the gravity of the planet to hold. Since Jupiter is not entirely a solid body, the equatorial regions bulge out. Your scope will show two dark equatorial bands spanning the disk. From time to time you'll glimpse the Great Red Spot, which represents a huge weather pattern. You may wonder why this spot is called "red." Its color has varied greatly over the years, and right now it's rather bland. Earlier this year a giant white spot encountered the Red Spot's turbulence; it will be interesting to note any long-term effects from the interaction of the two storms.

Seeing Jupiter's Galilean moons for the first time is simply unforgettable. They're easily visible in small scopes. Nightly recording of their positions around Jupiter helps identify their orbital motions. To Galileo, who lived at a time when the general understanding was that Earth is at the center of all heavenly orbits, such observations were revolutionary, at least in terms of humanity's quest to understand our world and its place in the universe.

By June 12, Venus moves in line with Castor and Pollux, and a crescent moon lies 2.4° from Jupiter. June 13 sees the growing crescent 2.2° above Venus. Both conjunctions provide for beautiful images of the sky, especially when silhouetted with a series of foreground objects.

Incidentally, while Jupiter and Venus are June's marquee features, **Mars** continues to linger in the evening twilight and traverses Gemini shining at magnitude 1.7. The Red Planet becomes invisible in the evening sky, but will reappear in the morning sky just as this year comes to a close.

In the far reaches of the dim, cold solar system, **Pluto** shines faintly at magnitude 13.8. Pluto reaches opposition on June 7, which also means that it lies due south at local midnight — the best time to view a planet. Pluto is wandering among a rich region of sky within the boundaries of Ophiuchus. The closest bright star to Pluto's location is Eta (η) Ophiuchi at magnitude 2.4, which sits in southeastern Ophiuchus. Pluto lies 2.4° north by northeast of this star. On June 10, Pluto lies near a magnitude 6.9 star. Plotting the star field around this star on a few nights either side of this date should reveal Pluto's motion, and it's the best way to positively identify the planet visually.

Shortly after midnight **Neptune** rises in the southeast, carried along by the stars of Capricornus the Sea Goat. Neptune shines at magnitude 7.9, and lies between Upsilon (υ) Capricorni and 19 Capricorni.

Uranus rises one hour after Neptune and has crossed from Capricornus into Aquarius the Water Bearer. Using binoculars, you can spot Uranus 1.3° north of the magnitude 4.2 star Iota (ι) Aquarii. Uranus shines at magnitude 5.8, and will appear to stand still relative to background stars during part of June as it begins its retrograde loop back to opposition in August.

Meteors and Moons

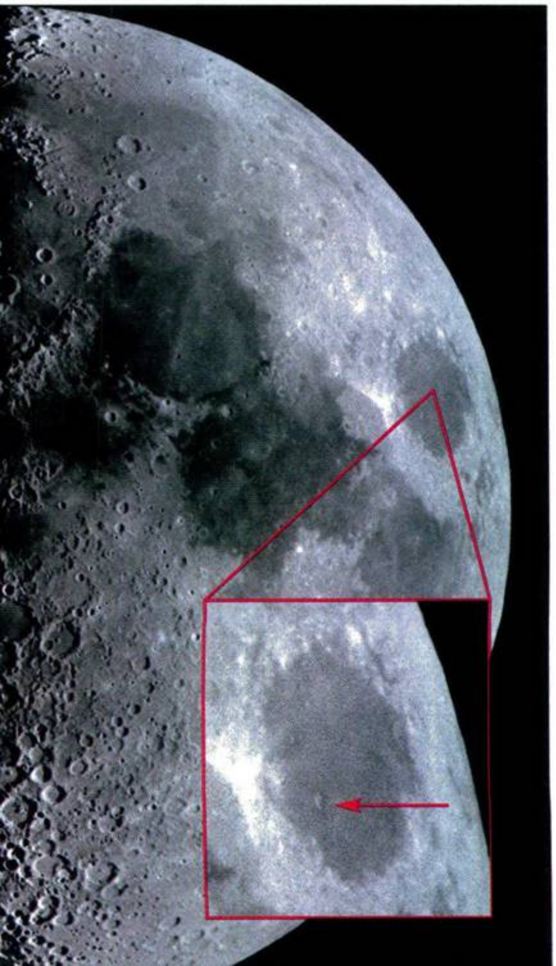
Meteors

There will be no major meteor showers this month.

Annular eclipse/Partial eclipse

A new moon occurs on the ecliptic in June — meaning it's time for a solar eclipse. On June 10/11 (depending on which side of the International Date Line you're located), an annular eclipse of the sun is visible from a narrow path that cuts across the Pacific Ocean. This eclipse is unusual since there is little landfall on the centerline. An annular eclipse occurs when the moon is farther from Earth than average, the maximum distance of which is known as the moon's point of apogee. As a result, observers on the centerline don't see the sun completely covered. A glowing ring, or annulus, remains at mid-eclipse. Observers near Puerto Vallarta in Mexico should see this remarkable annulus just as the sun dips and "touches" the horizon.

The glowing ring of an annular solar eclipse. John F. Berry



Mare Crisium (Sea of Crises) is pockmarked by the Picard Crater (see arrow). J. Paul Roux

Regions north and south of the centerline will witness varying degrees of a partial eclipse. Northern Australia, the Philippines, Guam, Japan, Hawaii, Alaska and most of Canada and the United States will experience a partial eclipse. The southwestern United States will experience the greatest partial phases near sunset on June 11, when the moon covers between 60 and 80 percent of the sun's disk. Cities farther north and east will see lesser degrees of coverage. Check out http://sunearth.gsfc.nasa.gov/eclipse/eclipse.html for more detailed information.

Moon feature: Mare Crisium stopped

When the moon is waxing crescent, its first dark "sea" in view is Mare Crisium (Sea of Crises). The craters that dot Mare Crisium's apparently smooth floor will first appear as dark pits, resulting from the sun illuminating them from the opposite side of our viewing direction.

During June, you may want to note just how close Mare Crisium lies to the limb of the moon compared to later in the year, when in September and October this lunar "sea" will appear farther from the limb. The apparent rolling of the moon over this time period is due to a curious phenomenon called "libration," which is caused by a combination of the moon's 6° orbital inclination and its elliptical orbit.

The largest crater on Mare Crisium is Picard, which is 14 miles (23 km) across. Due north of Picard is the smaller but equally prominent Pierce crater. The western wall of Mare Crisium appears fairly chaotic, with a couple of partially submerged craters and a long ridge running along the western flank.

Jupiter's satellites

Jupiter will soon succumb to the sun's glow and disappear for a few weeks. So June represents the last chance to observe jovian satellites until the planet reappears in the morning sky in late August. Rare occultations, transits and eclipses of Jupiter's fourth large moon, Callisto, continue this month. Only two events are visible, one from the United States and the second from Europe. During each 12-year orbit of Jupiter around the sun, only two series of eclipses involving Callisto occur. The current series began in September 2001 and continues until September 2004. Only 66 eclipses will occur in this time frame.

The events listed here are given in Universal Time (Greenwich Mean Time) and Eastern Daylight Time. Tr = transit; I = Ingress; E = Egress; Oc = occultation; Sh = shadow transit; Ec = eclipse; D = disappearance; R= reappearance. The events are worth viewing due to their relative rarity. Not all will be visible from the United States.

Callisto Events for June 2002

	UT	EDT	
June 5	5:08	1:08 A.M.	IV.Oc.D.
	9:45	5:45 A.M.	IV.Oc.R.
	12:37	8:37 A.M.	IV.Ec.D.
	16:43	12:43 P.M.	IV.Ec.R.
June 13	17:53	1:53 P.M.	IV.Tr.I.
	21:43	5:43 P.M.	IV.TrE
	23:17	7:17 P.M.	IV.Sh.I.
		11:22 P.M.	IV.Sh.E.
June 14	3:22		IV.Sh.E.

Will Comet Ikeya-Zhang have an outburst?

Vaulting into astronomical news in February, and leaping high into northern skies in April, comet Ikeya-Zhang is by now out of the limelight. But congratulations go to the Japanese and Chinese astronomers who patrolled the skies beyond the reach of the robotic cameras of the LINEAR and LONEOS programs and nabbed this comet.

As this issue went to press, predictions called for a naked-eye showing of Ikeya-Zhang in late March and early April. The indications are that in June the comet should glow around 10th magnitude and fade quickly to magnitude 11. As you may already know, some comets experience outbursts after they pass the sun, so there's a slight chance this comet may remain within reach of binoculars.

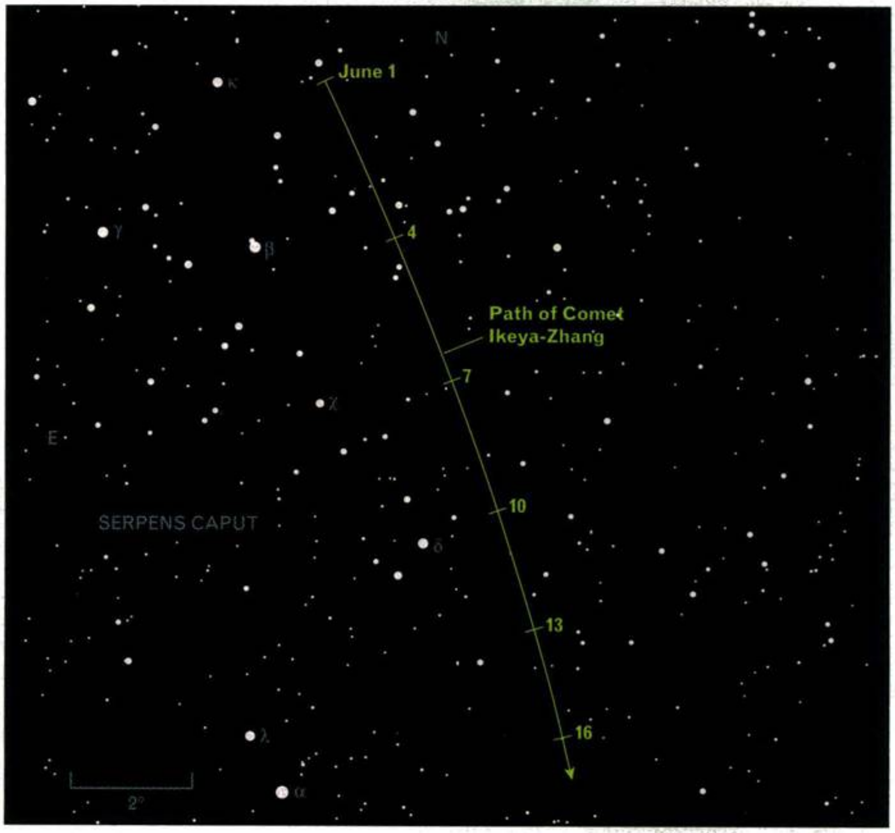
Ikeya-Zhang will roam the evening sky not far from the bright orange star Arcturus. Here is some tracking information for selected dates throughout the month: June 5 (15h07.5m, 8°39' [2000], mag. 9.3), June 15 (15h02.5m, 11° 37', mag. 10.2), and June 25 (15h02.0m, 6°20', mag. 11.0)

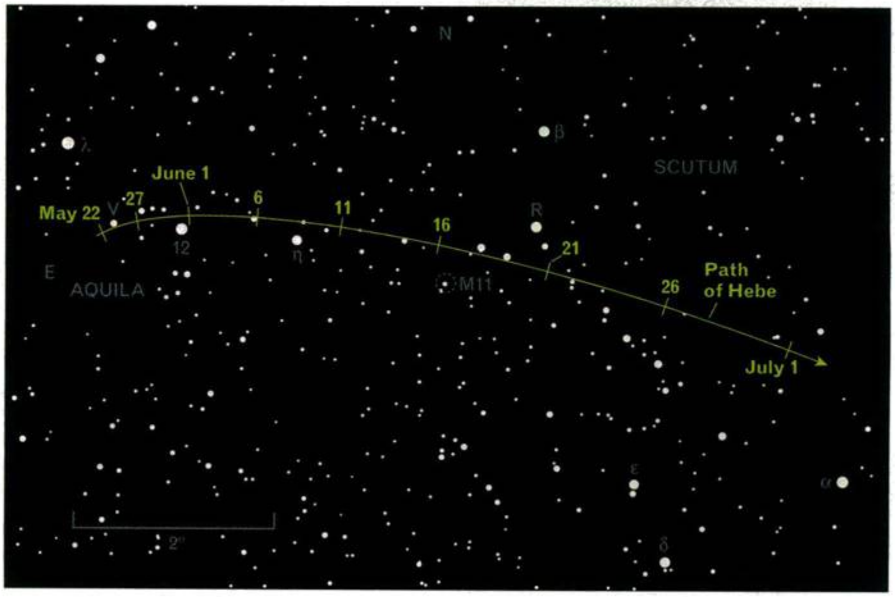
Check out NASA's comet website at http://encke.jpl.nasa.gov/ to get the latest information on comet activity and the ability to download pre-made star charts of Ikeya-Zhang's path, along with other well-tracked comets like LINEAR WM1.

Asteroid flocks with the Wild Duck Cluster

This month the minor planet 6 Hebe will be visible from the backyard in a 4-inch scope. Hebe glows at a respectable magnitude 9.6. Moon or not, you should be able to follow it across the Milky Way starfields of Aquila and Scutum. Once you locate the field with the map, move up to 100x to help bring out the starlike speck that is Hebe.

By the evening of June 6, Hebe forms a tight pair with a 7.3-magnitude star, making it easy to detect the asteroid's orbital motion. A repeat show occurs on June 9 with a slightly dimmer 8.4-magnitude star.





On June 17, Hebe flies about 20' north of the Wild Duck Cluster, which is one of the sky's truly impressive sights. Also known as M11, this magnificent grouping of stars is shaped in a V with a bright star near its apex. ■

Martin Ratcliffe is President of the International Planetarium Society and observes from Wichita, Kansas. Alister Ling is a meteorologist working for Environment Canada in Alberta.

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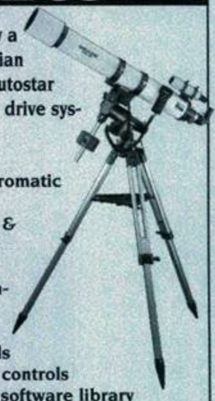

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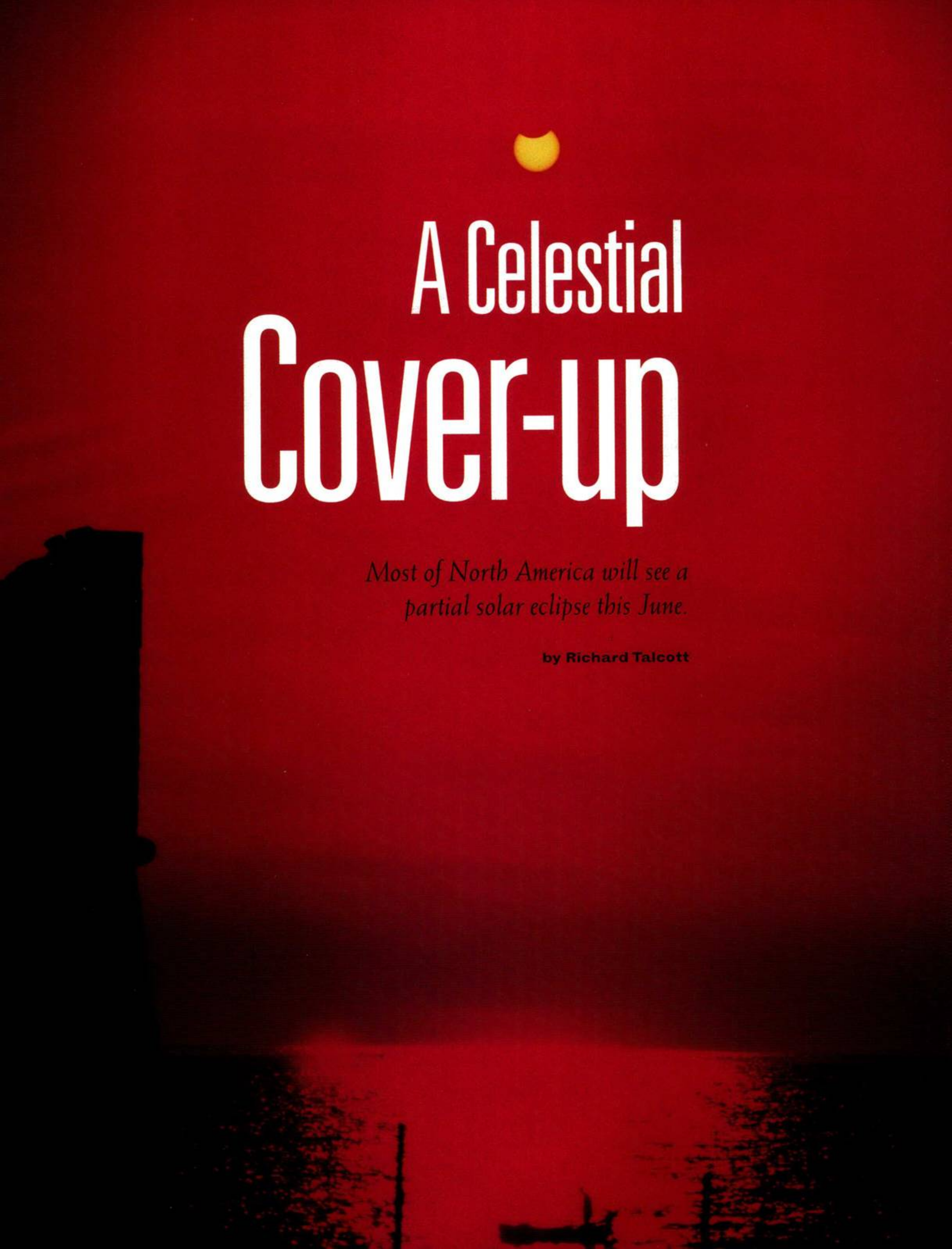
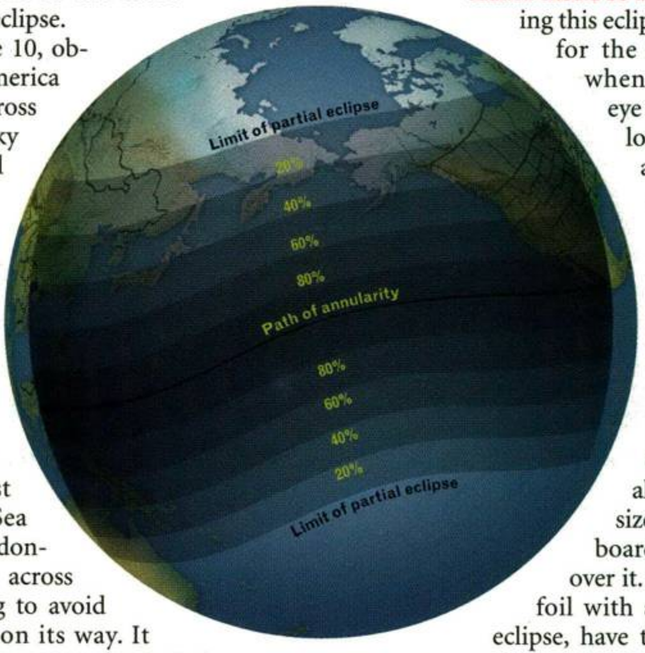


A Celestial Cover-up

Most of North America will see a partial solar eclipse this June.

by Richard Talcott

No one denies the beauty of a total solar eclipse: the delicate tendrils of the sun's corona, the fiery red prominences soaring above the moon's limb, the pinks and purples of twilight circling the horizon. But the blazing glory of totality shouldn't blind anyone to the more subtle pleasures of a partial eclipse.



June 10's solar eclipse will be annular for some; partial for most.

Gianni Tumino

On the afternoon of June 10, observers in most of North America will see the moon glide across part of the sun. And for a lucky few in Mexico, the moon will turn the sun into a dramatic ring of fire as together the pair sets gracefully into the Pacific Ocean.

This ring of fire, called an annular eclipse, occurs when the moon passes directly in front of the sun but appears too small to block it entirely from view. The path of annularity first hits Earth in the Celebes Sea just north of Sulawesi in Indonesia. It then treks eastward across the Pacific Ocean, managing to avoid all but a few small islands on its way. It reaches the Mexican coast about 15 miles (a little less than 30 km) south of Puerto Vallarta. On the centerline, the annular phase lasts 1 minute and 7 seconds and concludes just before the eclipsed sun sets in the ocean.

For anyone within about 2,500 miles (4,000 km) of the path of annularity, the moon takes a bite from the sun. This includes all of North America except for the East Coast of the United States, northeastern Canada, and southern Mexico. The moon covers just a tiny morsel of the sun's disk at the northern and southern limits, about half from Hawaii and along a line stretching from the state of Washington to Arkansas, nearly 80 percent from Southern California, and more than 90 percent from southern Baja California.

Eclipse Times and Circumstances

City	Eclipse Begins	Maximum Eclipse		
		Time	Altitude	Magnitude
Chicago, IL	7:28 P.M.	8:10 P.M.	2°	31%
Cleveland, OH	8:30 P.M.	9:04 P.M.	0°	26%
Dallas, TX	7:27 P.M.	8:22 P.M.	2°	58%
Denver, CO	6:21 P.M.	7:16 P.M.	11°	51%
Honolulu, HI	1:04 P.M.	2:42 P.M.	60°	52%
Los Angeles, CA	5:13 P.M.	6:22 P.M.	19°	77%
Minneapolis, MN	7:26 P.M.	8:08 P.M.	7°	29%
Phoenix, AZ	5:19 P.M.	6:24 P.M.	13°	73%
Puerto Vallarta, MX	7:31 P.M.	8:34 P.M.	1°	97%
San Francisco, CA	5:06 P.M.	6:16 P.M.	24°	72%
Seattle, WA	5:02 P.M.	6:04 P.M.	28°	48%
Toronto, ON	8:31 P.M.	9:01 P.M.	0°	20%

All times are local time

Caution should be the key word for anyone watching this eclipse. It takes just a few seconds for the sun to damage the retina when observing with the naked eye and a fraction of a second if looking through binoculars or a telescope. For a direct view, use only Mylar or metal-on-glass filters designed specifically for solar viewing (never use a so-called "sun filter" that screws on a telescope's eyepiece) or a #14 arc-welder's glass.

You can get a nice indirect view using two pieces of cardboard and some aluminum foil. Cut a modest-sized hole in one piece of cardboard and tape the aluminum foil over it. Then poke a tiny hole in the foil with a straight pin. To view the eclipse, have the sun's light pass through the pinhole onto the second piece of cardboard, which serves as a screen.

The simple pinhole camera forms an inverted image of the sun on the screen. Holding the screen closer to the pinhole provides a brighter image; moving the screen farther away yields a bigger image. By adjusting the separation of the two cardboard pieces, you can get the most pleasing combination of image size and brightness. A pinhole camera provides a great way to show the eclipse to a small group of people. It also works great with kids, with the added benefit that their eyes will be focused on the screen and away from the sun.

It's always fun to follow the moon's progress across the sun's disk, regardless of how much of the sun disappears from view. Once the moon covers half the sun or more, a perceptive eye notices that shadows appear sharper. By the time the moon blocks 80 percent of the sun, the sky becomes noticeably darker and colors seem more vibrant. Also look closely at sunlight filtering through the leaves of nearby trees and bushes — you'll see hundreds or thousands of tiny crescents. The openings between the leaves serve as pinholes, and each projects an image of the eclipsed sun.

Although a partial eclipse pales in comparison to a total one, it still provides a nice array of visual treats. And they are far easier to come by. After all, the June eclipse marks the third partial eclipse for North America in the past 18 months. We have to wait 15 years before totality hits home again.

A Happy Medium

Advance your observing sessions with Celestron's G-9.25 mid-sized telescope.

by Phil Harrington

Ever since it was introduced in 1970, the Celestron 8 Schmidt-Cassegrain telescope (SCT) has been one of the most popular telescopes for backyard astronomers. Capitalizing on its popularity, Celestron went on to develop several other SCTs for the amateur market, ranging in aperture from 5 inches to a whopping 14 inches. Tucked right in the middle is the Celestron G-9.25. This mid-sized telescope goes unnoticed by many amateurs, yet the 9.25-inch f/10 instrument is capable of producing fine images of both the planets and deep-sky objects. The extra aperture over its renowned 8-inch relative gives the Celestron G-9.25 more "oomph."

In the past, the California-made 9.25-inch Celestron has been sold on a number of different mountings. The current model, known as the G-9.25, is mated with Celestron's CG-5 German equatorial mount. Except for the addition of an extra counterweight, the CG-5 is the same mount that Celestron packages with several smaller telescopes, including the 8-inch G-8 SCT, 6-inch CR150-HD refractor, and G8-N Newtonian reflector.

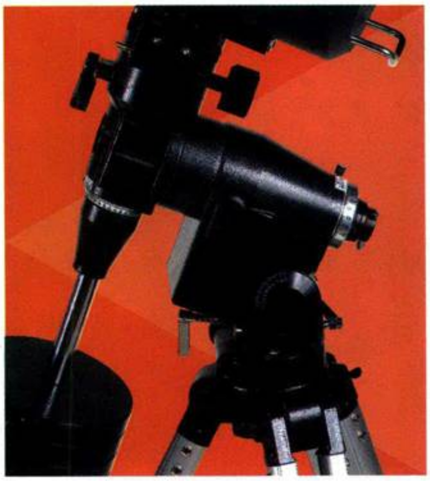
The CG-5 comes with manual slow-motion controls on both axes, a pair of setting circles, and a latitude scale for judging proper polar-alignment.

Astronomy: Jim Forbes

CELESTRON

In addition to the equatorial mount, the G-9.25 comes packaged with a 26mm Plössl eyepiece, 1.25" star diagonal, screw-on visual back, 6x30 finderscope, and an adjustable aluminum tripod with accessory tray.

Getting the telescope ready for a night under the stars was easy, requiring only two trips to bring the equipment outside. First, I set up the tripod and mount, which together weigh 33 pounds. I extended each aluminum tripod up to 53 inches, then secured them in place with a large thumb lever. To steady the base, a spreader — attached to the underside of the mount — presses outward against the legs. I placed the telescope tube onto the mount by slipping the metal dovetail bar that runs the full length of the tube into a mating bracket on the CG-5 and then locked it in place with a thumbscrew. A second, smaller thumbscrew serves as a safety just in case the first is accidentally loosened. Once engaged, I slid the tube back and forth until it was perfectly balanced on the mounting.



I evaluated the G-9.25 telescope's performance during the chill of winter, affording me an excellent chance to see how well the scope acclimates in the cold night air. As you probably know or will soon learn, air turbulence will disturb viewing until the instrument's optical assembly is close to the ambient temperature outdoors. Depending on both the telescope's aperture and the temperature gradient between the instrument's storage location and place of use, the image may take an hour or more to settle.

The G-9.25 took just about one hour to acclimate from a warm house to a cold yard, which is about average for this sort of telescope. What surprised me, though, was how the G-9.25 acclimated: For instance, one especially cold night I noticed that the images were dancing around terribly, even though the instrument had been outdoors for close to an hour. But then, almost like flicking a switch, the image suddenly steadied. Other telescopes, both large and small, usually ease into thermal equilibrium.

Once everything settled, the G-9.25 proved a real winner optically. Focusing was very smooth even in sub-freezing temperatures. And I detected only a slight hint of image shift, caused by the mirror not quite moving uniformly inside the tube as one turns the focusing knob. The "star test" — wherein a star's image is examined and compared on both sides of focus — confirmed the fine quality of the scope's optics. I saw little evidence of spherical aberration.

But such tests can only reveal so much about a telescope. The question simply becomes — how well can one observe with the G-9.25? To find out, I began with observing mighty Jupiter. The planet's belts were simply dazzling, with subtle colors and the most tenuous of detail seen steadily. Then I moved to Saturn, whose rings were very impressive, and both Cassini's Division and the C ring were easily visible.

Previous page: Celestron's 9.25-inch scope produces fine images of both planets and deep-sky objects. Above, center: The CG-5 equatorial mount. Next page: The aluminum tripod needs some strengthening.

Deep-sky objects were no less appealing. For instance, M42, the Orion Nebula, was wonderful, showing its gossamer clouds in all sorts of intricate contortions. Buried within the clouds, all four main stars in the Trapezium sparkled, and even the more challenging E and F Trapezium members shone through. Open cluster M35 was quite a sight through the G-9.25 when coupled with my 22mm Tele Vue Panoptic, while its dimmer, more distant neighbor, NGC 2158, dissolved into a stellar fizz of light when viewed with my 12mm Nagler eyepiece. I even saw hints of spiral structure in the face-on Whirlpool Galaxy (M51). I devoted the rest of my viewing with the G-9.25 to some of the many fine deep-sky objects that fill the winter and early spring skies. The telescope delivered consistently good images of these celestial gems — a sign of superb optical quality.

The 26mm Plössl eyepiece included with the G-9.25 is a well-made eyepiece, which features fully coated optics that suppress flare from bright objects such as Sirius and Rigel. Even still, owners may want to expand their eyepiece collection.

While considering eyepieces, give some thought to upgrading the finderscope. The supplied 6x30 finderscope is fine to start with, but you'll soon find that such a small aperture makes star-hopping difficult. Most experienced observers agree that an 8x50 is the smallest useful size, which will penetrate to about 8th or 9th magnitude, the same as several popular star atlases. Celestron sells an excellent 9x50 finder, while several other manufacturers also offer good selections of finders. Fortunately, the mounting-hole spacing for finder rings on SCTs are all standard, regardless of the finderscope's size, so it's an easy switch.

It turns out that the CG-5 mounting is the G-9.25's Achilles' Heel. The 25-pound optical tube is just too much for the CG-5 to support steadily. Vibrations make focusing images difficult, especially at higher magnifications.

As a quick check of a mounting's suitability, I always do what I call a "rap test." While viewing through the telescope, I lightly hit the tube with the ball of my hand and count the number of seconds it takes for the vibrations to settle out. On my purely arbitrary scale, I have assigned a dampening time of zero to three seconds an "excellent," three to six seconds "good," six to eight seconds "fair," and more than eight seconds as "poor." The G-9.25 mounted on the CG-5 mount continued to reverberate for more than 11 seconds.

The guilty party here is the aluminum tripod. Like many imported tripods, the CG-5 is made from thin-walled, stamped aluminum. The stamped shape twists and torques whenever the telescope is moved or tapped, which causes the image to dance and shimmy.

Fortunately, though, this type of tripod is supplied with many different refractors, reflectors, and catadioptric, or "hybrid," telescopes throughout the world, so some amateur astronomers have investigated this stability issue and discovered ways to steady the situation.

One simple fix seems obvious: Make sure everything is tight. Often, as telescopes are transported and swung to and fro, screws can loosen just a bit. Connections that are even slightly loose may cause problems. Places to watch: the altitude adjustment and the mount/leg connections.

Another trick is to fill the hollow tripod legs with an inert material. Some have suggested sand, but a better choice is foam insulation from an aerosol can. The foam sprays out as a liquid, but quickly expands and solidifies, filling the voids in the legs. Best of all, there is effectively no increase in the instrument's weight. Placing a set of vibration pads sold by Celestron under each leg also helps, as does suspending a weight, such as a gallon jug of water, just off the ground from directly under the mount.

Even with these improvements, wood still has much better vibration-dampening characteristics than metal. NatureWatch (P.O. Box 22062, 24 St. Peters Road, Charlottetown, PE, Canada C1A-9J2; phone 800–693–8095; www.naturewatchshop.com) sells nicely crafted, extendable tripod legs made from oak that are designed specifically as replacements. Purchasers say that the difference is well worth the price of between $120 and $200.

Like nearly all equatorial mounts, the G-9.25 comes outfitted with a pair of setting circles. Once the equatorial mount is aligned to the celestial pole (an optional polar scope is sold, which makes this task significantly easier), an observer can dial in the right ascension and declination coordinates of an object and aim the telescope without having to star hop. Setting circles always sound very attractive to those new to astronomy, and indeed, to many veteran observers, since they should let the user find objects more quickly. But for an object to appear exactly centered in an eyepiece's field of view, you must finely calibrate the setting circles. The circles on the G-9.25 mount, however, like those included with many amateur telescopes, are only accurate enough for pointing the instrument in the general direction of an object; you may still have to do some searching.

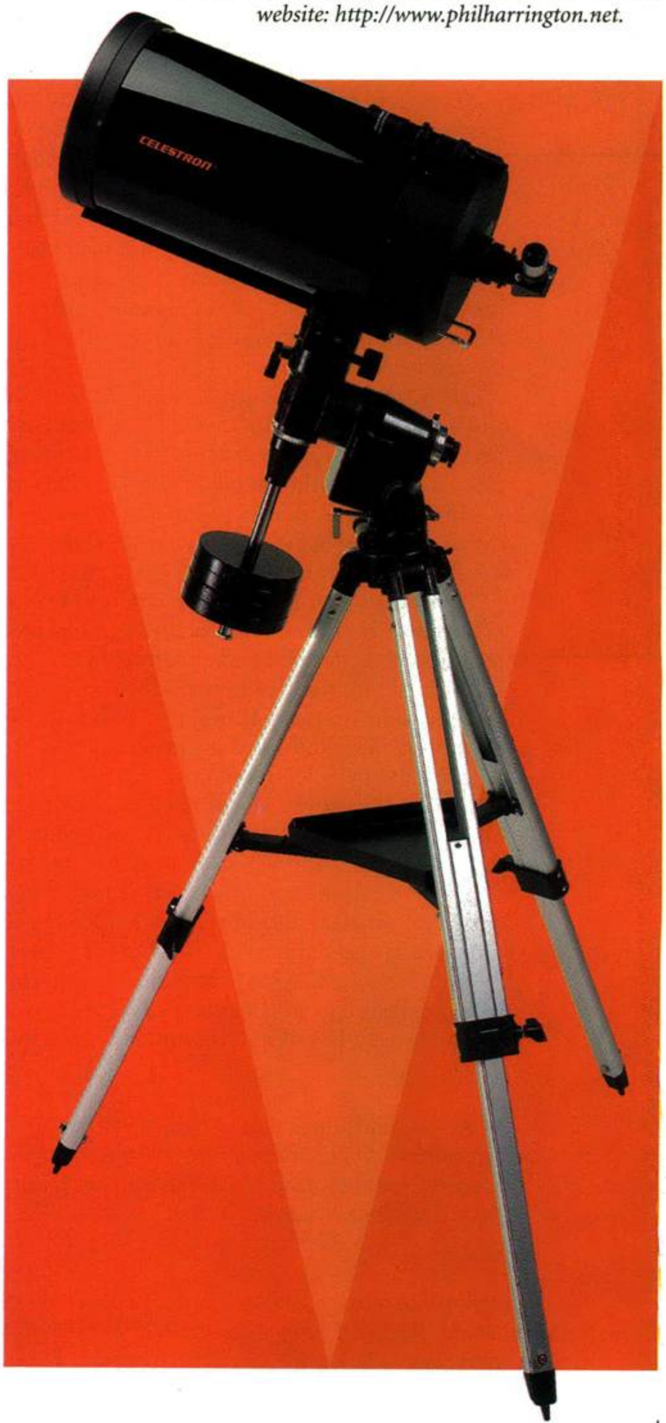
You can also outfit the CG-5 with either single-axis or dual-axis DC-powered tracking motors, although neither was used in this test. With the tracking motors on, the telescope follows the sky slowly and steadily on its own, which lets vibrations dampen out fully — a big help when trying to spot elusive detail on a planet or a deep-sky object. The single-axis, right ascension drive retails for about $125, while the dual-axis drive costs around $200. Another good accessory to consider is a dew cap to prevent the corrector plate from fogging over. I also recommend using a chair or stool to maximize your comfort level while observing.

The bottom line is that the G-9.25 is something of an enigma. The optical assembly performs well and the images are very sharp. But the equatorial mount is too flimsy to do the telescope's fine optics any service. Even with the improvements outlined earlier, the 9.25-inch is just too much telescope for its mount and tripod to support. ■

Phil Harrington's equipment reviews appear often in Astronomy. *His book,* Star Ware, *is available at bookstores and his website: http://www.philharrington.net.*

Specifications

Aperture: 9.25 inches
Focal Length: 2350mm
Focal ratio: f/10
Optical design: Schmidt-Cassegrain telescope (SCT)
Secondary Mirror Obstruction: 3.35 inches (36% by diameter, 13% by area)
Optical tube length: 24 inches
Telescope Weight: 58 lbs
Mount: CG-5 German equatorial mount on adjustable aluminum tripod
Accessories: 26mm Plössl (90x), 1.25" Star Diagonal, 6x30 finderscope, accessory tray
Manufacturer's Suggested Retail Price: $2,598
Typical "street price": $1,250 - $1,350



Beginner's sky

Diary of a neophyte astronomer. By Jerry Burstein

It's a Small World After All

Relax — I haven't given up on stargazing and run off to Disney World. Allow me to explain . . .

I've spent the last few weeks doing some occasional naked-eye stargazing. (It's still a bit chilly here in the North.) I've also been trying to get better at using a planisphere. (And no, that's not the small world I'm referring to.) While my sidekick and I worked on identifying new celestial objects, we made a different sort of discovery this past month.

Less than a mile from where we live, tucked a good bit off a narrow country road, stands a lonely observing dome. Who would have guessed that my daughter goes to school with the kid who lives there? Even better, a recent school function brought me face-to-face with Dick Adduci, the owner of what is fondly known in these parts as the Eagle Observatory.

After talking with Dick, I quickly realized that he was a very dedicated amateur astronomer. His card lists no fewer than 14 astronomical societies and associations, and the initials F.R.A.S. (Fellow of the Royal Astronomical Society) follow his name. It didn't take long before I invited myself over to see his elaborate setup.

A few days later my daughter and I were treated to a tour of his home-built facility. A motorized 10-foot fiberglass dome sits atop half of an out-building nestled among Dick's 36 acres.

The dome houses a 12-inch SCT on a 16" concrete pier. Dick controls everything from an adjacent 10' by 10' library/computer/warm room. For an excellent overview of what we saw, check out Dick's website at http://www1.wcf.net/~radduci/eagle/index.html.

Dick's dedication to this hobby is inspirational and he offers clear and simple advice: Read. Plenty of books are geared toward "newbies." As Dick says, "Find the books that truly provide meat on the subject and absorb as much as you can."

I've listed a few of his recommendations below:

The Stars: A New Way to See Them
H. A. Rey (of Curious George *fame), 160 pages, Houghton-Mifflin, Boston, 1976; ISBN 039248302; paperback, $11.95. (Dick calls* The Stars *a "ground-floor Bible for all newbies.")*

The Backyard Astronomy Guide
Terence Dickinson and Alan Dyer, 298 pages, Firefly Books, Westport, Connecticut, 1991; ISBN 0921820119; hardcover, $39.95.

Touring the Universe through Binoculars
Phil Harrington, 304 pages, John Wiley and Sons, New York, 1990; ISBN 0471513377; paperback, $35.

My sidekick and I are looking forward to going back to Eagle Observatory (on a warmer night) to see it in action. We feel lucky with our nearby discovery. It proves that you just never know — similar opportunities might well turn up in your area. So if you think you've spotted an observing dome, or if you happen to run across someone who's set up a telescope and who welcomes visitors, check it out and see what you discover.

It really is a small world, after all.

Please send me your thoughts on astronomy and any suggestions for topics you'd like to see covered in these pages. Keep those e-mails and comments coming to *jerry@astronomy.com*.

Sagittarius Offers Summer Splendor

Summer is the time for Milky Way dreaming when we can once again see the river of stars that comprises our galaxy. One of the more interesting naked-eye regions to explore, the constellation Sagittarius, lies in the direction of the galactic center. Face south in the late evening to spot it between Ophiuchus and Capricornus. Although it is known as the Archer, and shown on early celestial charts as a centaur aiming its bow and arrow at nearby Scorpius, the best way to recognize Sagittarius is by its asterism — a teapot.

Just like the "I'm a Little Teapot" song, this celestial vessel is short and stout as well. Its spout points into the Milky Way, with its handle jutting off to the left.

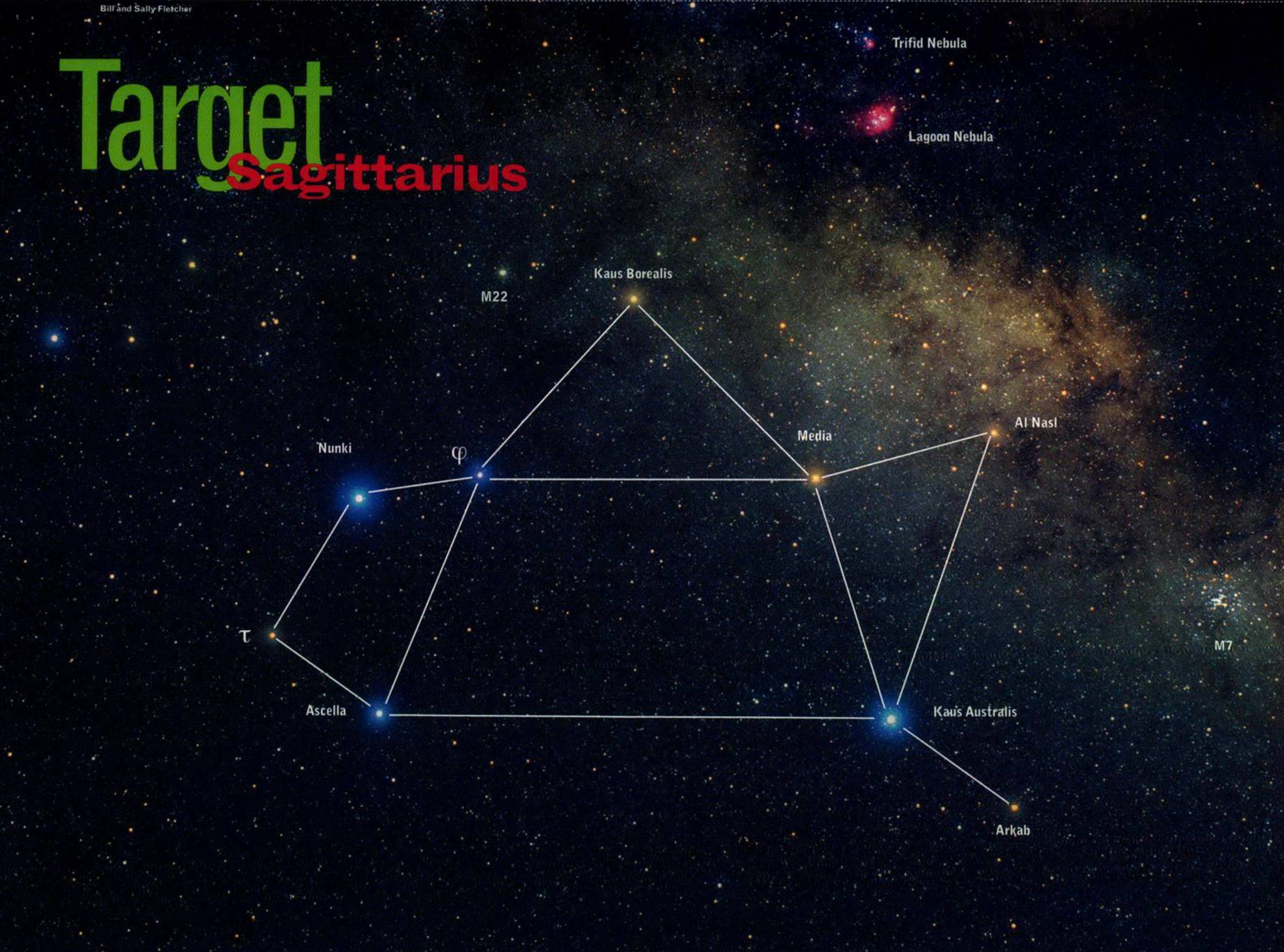
The teapot's brightest stars, Kaus Australis and Nunki (magnitudes 1.8 and 2.1, respectively) shine from opposite ends of the asterism and were first cataloged in the *Almagest* by the astronomer Ptolemy almost 2,000 years ago. Since then, modern astronomers have identified the Sagittarius Dwarf Galaxy and a strong radio source, Sagittarius A, nearby. This latter object contains an object called Sagittarius A* — pronounced "Sagittarius A Star" — and is believed to lie at the exact center of the Milky Way.

And get out your binoculars or telescope, for Sagittarius offers up several nebulae, positioned above and around the teapot. Named for their shapes, such as the Trifid Nebula (M20) and the Lagoon Nebula (M8), these objects are favorites among observers. Make them your favorites, too.

cut along dotted line

Bill and Sally Fletcher

Target Sagittarius


Trifid Nebula
Lagoon Nebula
Kaus Borealis
M22
Al Nasl
Media
Nunki
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Ascella
Kaus Australis
Arkab
M7

Beginner's zodiac

Zodiacal Signs Basic to Astronomy

The public often confuses astronomy and astrology. In some respects this is understandable; after all, both endeavors use celestial activity for inspiration. But while astronomers research and study the science behind cosmic phenomena, astrologers "read" the heavens, believing that the motion of heavenly bodies somehow influences human affairs.

Ancient Greeks identified star groupings according to what they imagined were human or animal figures appearing in the sky. This 360° band of star groupings — the zodiac — surrounds the celestial sphere on either side of the ecliptic. The zodiac subsequently divides into 12 equal parts named after the dominant constellation within: Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpius, Sagittarius, Capricornus, Aquarius, and Pisces.

In astrological parlance, one might hear something like: "When you were born your sun was in Taurus and your moon was in Gemini." At certain times in astronomical history such a statement may have been correct. However, if one examines a recent epoch constellation chart, the sun actually moves west of its traditional zodiac constellations — disappointing those who believe their birthdays are inexorably linked to a zodiacal sign. In fact, today the sun actually teeters on the edge of the preceding zodiacal constellations.

Precession Causes Change in Perspective

Such apparent solar straying is caused by precession, Earth's wobble about its rotational axis as it spins, much like the changing axis of a spinning top. Earth's northern polar axis currently points toward Polaris. Over thousands of years, Earth's rotational axis moves about in a circular path, changing our view of the stars. In fact, the tips of Earth's axis — the celestial poles — trace out a large circle against the celestial sphere every 25,800 years. This axial movement causes a slow westward shift of the celestial equator along the ecliptic, thereby upsetting the traditional month the zodiacal constellations are expected to host the sun, moon, and planets.

Still, astrological purists shouldn't fret, for as Earth's precessional period advances, the "correct" zodiacal constellation for a given birthday will be in its place many thousands of years from now. — *Paul Morledge, associate editor*

Glossary

Azimuth Angular distance measured clockwise around the observer's horizon in units of degrees; north is 0°, east 90°, south 180°, and west 270°.

Comet Minor member of the solar system in an eccentric orbit. As it approaches the sun, its nucleus of ice and frozen rock produces gas and dust debris tails stretching over millions of miles and pointing away from the sun.

Ejecta Material such as rock, dust, and fragments thrown out from an impact crater or basin during formation.

Limb The apparent edge of a celestial body's disk.

Parallax The angular displacement in an object's apparent position when viewed from two widely spaced points.

Parsec Short for "parallax second" and abbreviated as pc; a unit of length used for cosmic distances; one pc equals 3.26 light-years.

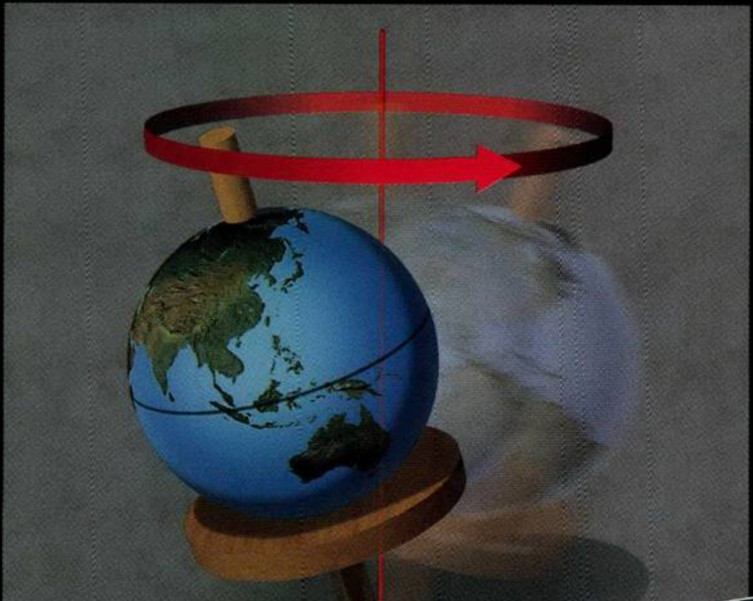
Solar flare A sudden, short burst from the sun's upper chromosphere or inner corona that sends radiation and solar plasma into space.

Solar prominence Dense gas clouds in the sun's upper chromosphere or inner corona that project beyond the sun's limb. A quiescent prominence is a fairly stable structure that can persist for several months; active prominences change appearance quickly and often last only minutes.

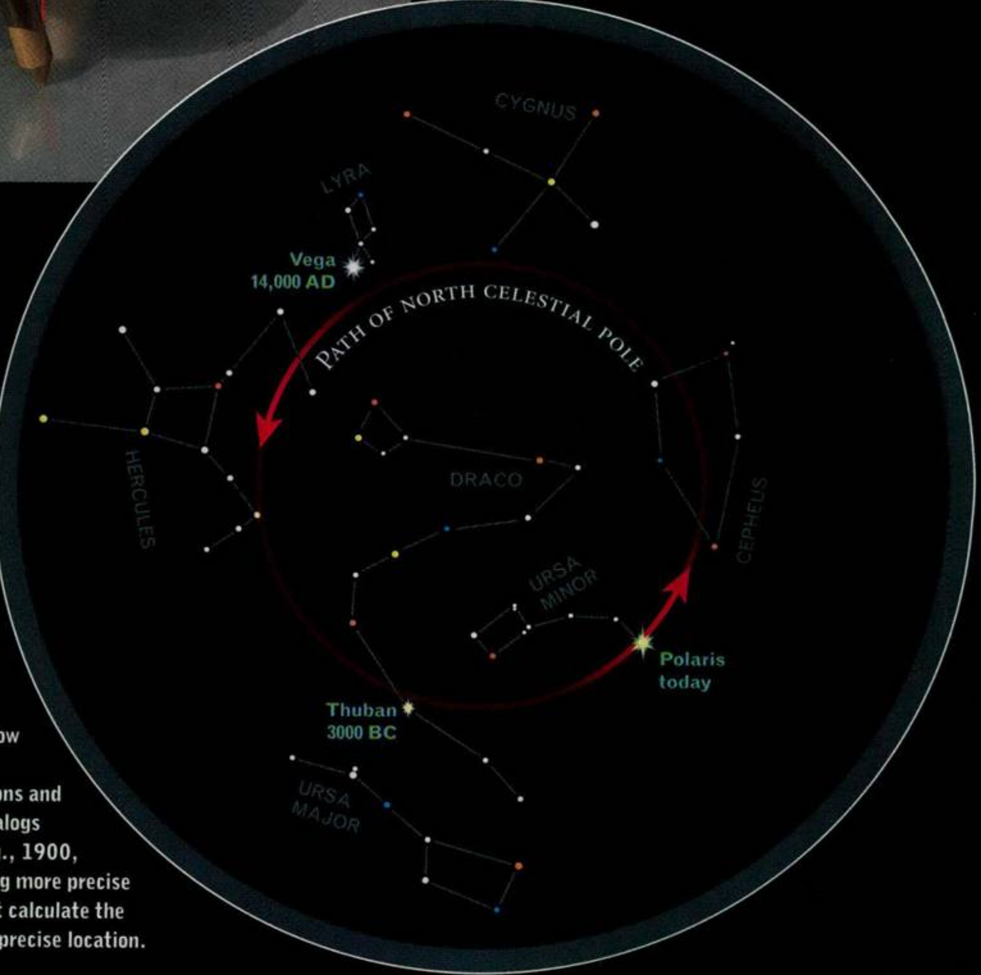
Sunspots Dark patches (actually magnetic storms) on the solar surface (photosphere) that are about 2,000° C cooler than the surrounding area; they give off light that is about ten times brighter than the full moon.

While you may find some new terms among these entries, many of them appear in articles throughout this issue.

Earthly precession



Precession happens because the gravitional forces of the sun and moon act on the non-spherical Earth as it rotates, slowly changing the orientation of Earth's axis. The axis, tilted at an angle of 23°, traces out a path around the ecliptic that takes 25,800 Earth years to come full circle. This means that Polaris — the star we currently consider our north celestial pole star — will slowly yield its position to Vega, the bright star in the constellation Lyra. However, don't worry about confusing Polaris and Vega anytime soon; this scenario is 12,000 years away.



That our celestial pole gradually changes its orientation to the stars affects the movement of the celestial equator relative to the ecliptic. And as the intersection of the celestial equator and ecliptic moves clockwise at about 50 arcseconds per year, it gradually shifts the equinoxes. In turn, gravitational attractions of other planets also affect the orientation of the plane of Earth's orbit in a process called planetary precession. General precession results from all the precessional forces working together. Star catalogs and charts measure celestial positions from the vernal equinox. Thus, the slow creep of the plane of Earth's orbit requires an adjustment in star locations and necessitates the updating of star catalogs according to a particular equinox (e.g., 1900, 1950, 2000, 2050). Anyone requiring more precise star coordinates for a given year must calculate the amount of precession to determine a precise location.

Cloudcroft Astronomy

by Tom Polakis

Tell anybody in your community that you are an astronomer and you're likely to get a strange look. Not so in Cloudcroft, New Mexico, a town with an astronomical presence that is unparalleled in the country. On a recent trip, this point was brought home to me early on when I stopped in the town's lone convenience store, which also serves as gossip central.

After an episode of small-town interrogation, the clerk learned that I was spending a couple nights at Apache Point Observatory, just down the road. Her first question was, "How is that secondary mirror for the Sloan telescope doing?"

Located amid the 1.1 million acres of Lincoln National Forest, Cloudcroft is a mountain community of 600 inhabitants located two hours northeast of El Paso, Texas. The nearest sizeable town is Alamogordo, 22 road miles and 5,000 feet below. The drive into Cloudcroft begins in mostly featureless desert and culminates in a gorgeous forest of spruce, fir, and ponderosa pine. Despite its southerly latitude, Cloudcroft enjoys a cool mountain climate and winter snow. All this contributes to an unmatched astronomical neighborhood. And astronomers are moving here in droves.

Cloudcroft began to take off when Jim Riffle moved there in 1987. From his observatory on 22 secluded acres, Riffle often experienced the best of astronomical conditions: subarcsecond seeing and premiere sky darkness and transparency.

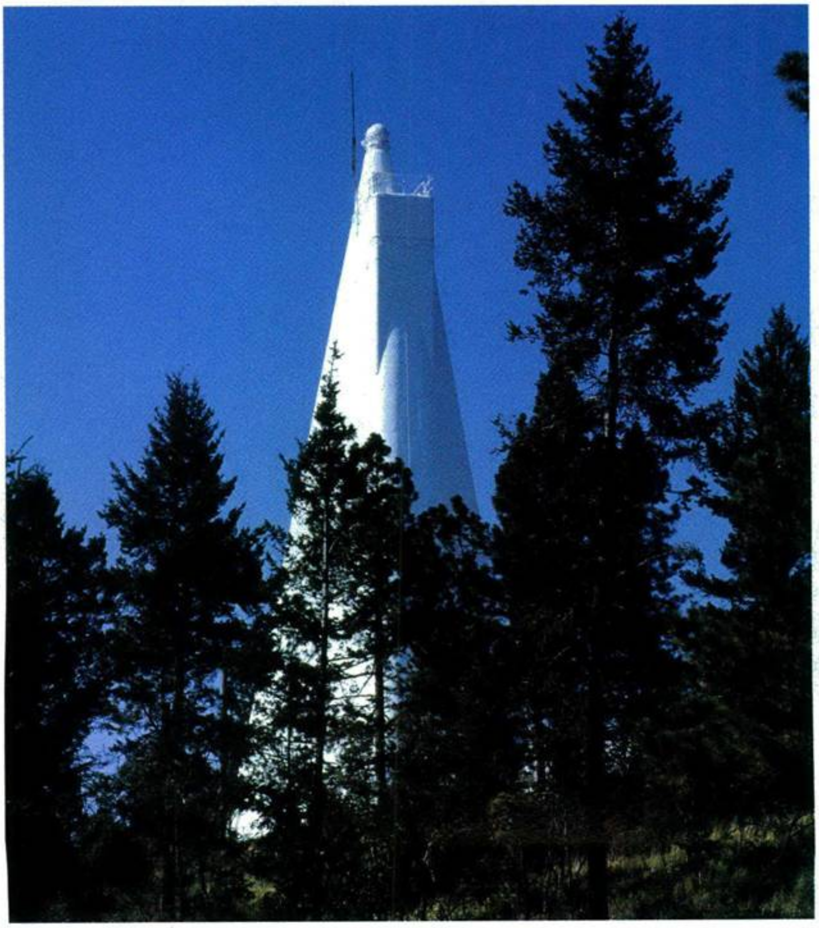
From his current home in western Arizona, he fondly remembers days after snowstorms "when you could block the sun with your finger, and the sky was dark blue to the edge." He wasn't so fond of maintaining a mile-long driveway that rose 400 feet. This aspect of overcoming the harshness of remote living is a common theme among the astronomers of Cloudcroft.

Riffle currently produces for sale an 18-inch f/2.8 telescope suited for CCD imaging and photography. It is an appropriate followup product to the 12-inch f/5 Astromak that he manufactured during his days in New Mexico. Through Riffle's promotion of the area, other recognizable amateurs moved in, including Howard Brewington, who discovered four of his five comets from a site nearby.

Perhaps the most familiar is Alan Hale, whose serendipitous co-discovery of Comet Hale-Bopp elevated him into national attention. A meticulous visual comet hunter who doesn't shy away from the faintest ones, Hale fame was a result of "killing time" during an unusually clear July evening while he waited for a catalogued comet to clear his roof.

Hale acknowledges that the romantic days of amateur comet finds may be coming to a close. The Lincoln Near-Earth Asteroid Research (LINEAR) facility 200 miles from his doorstep now dominates the comet-discovery field with its large detector and robotic instruments. But as Hale once told LINEAR principal investigator Grant Stokes, "I found the best; you found the rest."

Greg Crinklaw shares Hale's simple approach to astronomy. Since his move from San Diego in 1998, Crinklaw has used his 18-inch scope to full advantage. Content with the sky view from his yard, he never travels in search of a better site. He is trained in astronomy but remains content with simply look-



The 136-foot Dunn Solar Telescope at the National Solar Observatory. Tom Polakis

The 3.5-meter ARC telescope at Apache Point Observatory. Tom Polakis

ing through the eyepiece in this "visual observing phase" of his life. He taught community-college astronomy courses and wrote the image processing software for the Mars Observer while at Malin Space Science Systems. He now produces SkyTools observing software. In a market packed with competitors, Crinklaw proudly mentions that his software's advantage is its suitability for planning, charting, and logging observations. He maintains the Skyhound Web site, which provides amateurs with observing tips and the latest astronomical news.

On the other end of the complexity scale stands New Mexico Skies, the country's finest guest observatory. Since moving from Alaska in 1998, proprietors Mike and Lynn Rice have worked to perfect the operation. Guests at New Mexico Skies have access to an array of instruments. Domes hold 16-inch, 14-inch, and 12-inch Schmidt-Cassegrains, as well as a 7-inch refractor, all equipped with CCD cameras. Dobsonians of 30, 25, and 15 inches stand on the expansive observing deck. Visitors to the site are often wowed by their first view of a really dark sky.

The Rices own 35 acres and control 11 more out to a National Forest boundary to ensure that no one nearby will be able to build at a higher elevation. In addition to their hospitality, the proprietors have a great working knowledge of astronomy and a keen interest in observing at all hours. New Mexico Skies won't become an overflow hotel for business; this space is astronomers only.

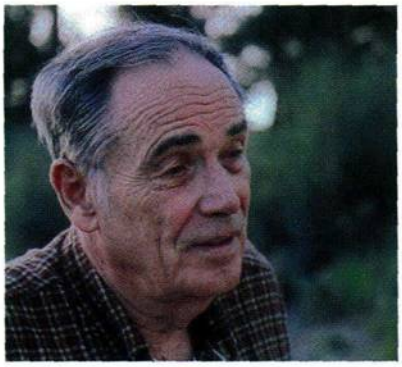
Amateurs monopolize the vicinity of New Mexico Skies. Among the owners of five large pieces of adjacent astronomical property is Andy Homeyer, who retired to the area from Southern California after an engineering career. He lives happily near the poverty level with his toys at the site of his dreams. In addition to working in an observatory that houses 11-inch and 7-inch scopes, Homeyer has an interest in manufacturing custom products for advanced amateurs.

By now you may think living in Cloudcroft is easy. It isn't. One hardship of great astronomical sites is an arid climate. Wells deeper than 600 feet are not uncommon, and a spell of dry years since 1992 has taxed some of them to their capacity. Drought has translated to fire danger, as the scorched remains of the forest on a nearby ridge testify.

While astronomical conditions are among the best in the country, don't expect it to be clear more than half the time. Slightly less than one night in three is photometric — clear from dusk to dawn — and twice as many nights are usable. During summer, Gulf moisture wipes out deep-sky viewing in New Mexico for weeks at a time. There's a reason for the "cloud" in Cloudcroft. Despite these drawbacks, three professional observatories recognize the astronomical superiority of Cloudcroft. The visibility of professional astronomers in the community can only improve the situation for amateurs.

A 14-mile drive down a magnificent, winding mountain road takes you to two professional facilities on Sacramento Peak near the village of Sunspot. First to appear at the site in the late 1940s was the National Solar Observatory (NSO). The 1990s brought Apache Point Observatory (APO) to the area. Both are positioned on a westward-facing precipice to take advantage of the prevailing winds from the valley below and attendant steady seeing conditions. Professional astronomers are frequently more interested in steadiness than transparency.

The centerpiece of the NSO is the Dunn Solar Telescope. The peak of the odd-shaped structure stands 136 feet above ground, representing just over one-third of the light path. The view from the top takes in the Hilltop Dome, home of the world's



Celebrated Cloudcroft resident Warren Offut discusses his observatory. Tom Polakis

Chief observer Anna Scott of the Orbital Debris Observatory. Tom Polakis

Alan Hale, codiscoverer of Comet Hale-Bopp, reflects on comet hunting. Tom Polakis

first reflecting coronagraph. Other Hilltop Dome scopes are used to take patrol images of the sun in white light and the H-α band. Because solar astronomers have no shortage of light, diverse instruments are positioned on an eight-sided spar, each receiving their own ration of sunlight. Telescope operator Brian Armstrong touts the facility's ability to quickly change out these instruments to suit the needs of research astronomers. Across the way is the Evans Solar Facility, a cone-shaped enclosure that houses a large coronagraph and a coelostat used to observe the solar corona and spectrum.

But the Dunn Solar Telescope is the instrument garnering the most superlatives. The high elevation above the surroundings experiences seeing so good that data is considered unusable when it is worse than 1". The f/72 optic has an almost unimaginable 180 feet of focal length. The entire instrument on its central column weighs 250 tons, yet one person can rotate it manually on its mercury bearings. An evacuated light path ensures against image-degrading tube currents, and some of the world's most advanced adaptive optics are employed near the focus.

NSO director Steve Keil notes that the Vacuum Tower telescope enjoys better seeing than the McMath telescope on Kitt Peak. The two instruments serve different purposes: the McMath specializes in chromospheric study while the tower telescope does high-resolution magnetic field work. Keil says that the only competition for the Dunn telescope is the Swedish Solar Telescope on La Palma in the Canary Islands. The NSO plans to create the ultimate solar instrument with the Advanced Solar Telescope. This will be an instrument of 4 meters, employing adaptive optics that are capable of achieving a resolution of better than 0.1".

A short drive to the south brings you to the Apache Point Observatory. Telescope engineer John Briggs works with the Sloan Digital Sky Survey instrument, one of four telescopes at the site. One of his jobs involves deploying a differential-image motion monitor that provides seeing measurements. An instrument so simple as a commercial Schmidt-Cassegrain telescope performs this task admirably. In addition to the stable air so important to APO's success, the transparency 9,000 feet up isn't bad, either. Only ten air miles away are the 30,000 inhabitants of Alamogordo, but a tough lighting ordinance cuts the town's glare to a local glow in the west.

Briggs is an "amateur's professional" and quick to change the subject to astronomy as a hobby. There is no formal club of Cloudcroft amateur astronomers, but in this small town he is familiar with everybody's astronomical work. Known in the area for his impressive collection of antique telescopes, one of Briggs' most recent additions is a classic Warner & Swassey 15-inch he hauled to New Mexico from the U.S. Naval Observatory.

Apache Point site operations manager Bruce Gillespie, whose day job holds the facility together, compares his work to a movie producer. Gillespie has a certain pride about the instruments at the observatory, and begins with the 3.5-meter run by the Astrophysical Research Consortium (ARC) — an organization of seven universities and roughly 200 astronomers who use the 3.5-meter telescope. Dedicated on May 10, 1994, the day an annular solar eclipse passed over the observatory, the telescope is a marvel of modern technology in a small package. The 3.5-meter uses such innovations as a rotating tertiary mirror to direct light to one of nine available instrument ports. It is competitive with Kitt Peak's similar WIYN telescope owing to the peak's unwavering atmosphere.

Precariously poised over the cliff is the 2.5-meter Sloan Digital Sky Survey telescope. Gillespie says "it's easier to go out than up" to avoid seeing degradation by the surrounding terrain. When operating, the telescope actually stands free of an enclosure, protected from the elements only by a wind baffle that is isolated from the tube. The enclosure rolls back from the instrument, an idea that Gillespie notes was borrowed from amateurs. From Sloan's deck he shows off a view of the Tularosa Basin that encompasses a land area the size of Massachusetts.

The Sloan Digital Sky Survey is an ambitious five-year project that will cover one-fourth of the sky's 40,000 square degrees. During this period, more than 75 percent of the time will be spent doing spectroscopic observations that will ascertain distances to nearly one million galaxies and 100,000 quasars, a daunting task accomplished with fiber-optic spectroscopy. During an observation, one of 2,000 plug plates containing 600 holes corresponding to known galaxy locations feeds spectra through fiber-optic lines. At the conclusion of the project, astronomers will possess a three-dimensional map of a quadrant of the universe that is unrivalled to date. On 100 of Sloan's nights, the telescope will perform CCD imaging in five photometric bands, creating humanity's greatest visual atlas of this quarter of the sky. The volume of photometric data, expressed in terabytes, is similar to that of the human genome project.

In Sunspot, Mark Mulrooney has just completed his thesis about a special type of telescope that employs a mirror whose coating is a terribly thin sheet of mercury spinning on a turntable. It is not a novelty item. Liquid mirrors enable large aperture telescopes to be constructed on a tight budget. A mercury layer only 1.5mm thick holds its form as long as the base rotates at a constant speed.

Mulrooney is project scientist for the largest liquid-mirror telescope in the world, NASA's Orbital Debris Observatory. Several miles from Cloudcroft, an observatory is home to a 3-meter instrument costing $1 million, less than 10 percent the price of a conventional telescope. The giant parabolic dish rotates at 10 RPM on a high-pressure air bearing necessary to prevent surface ripples. The bearing is so smooth that a full day passes after powering down before the turntable coasts to a halt.

The obvious limitation of a liquid mirror is its inability to point anywhere but the zenith. Given the telescope's purpose, lack of pointing is not of concern. The project's goal is to statistically survey space debris as small as 1cm. At a height of 1,000 km, a particle would glow feebly at 19th magnitude and be detectable by the image-intensified video camera. The survey will not catalog objects as much as it will determine the population of potentially harmful debris for orbiting manned space missions.

Creaking like a haunted house, the Liquid Mirror Telescope's enclosure is a cavernous structure of old-school design that was abandoned by the Air Force for 20 years before the current installation. Chief observer Anna Scott shows a half-hour video of "greatest hits" of the Orbital Debris Observatory, during which barely 10 seconds goes by without the passage of space junk. Coasting through the half-degree frame at the sidereal rate is the Ring Nebula, which happens to pass within a few arcminutes of the zenith at Cloudcroft's latitude.

Scott carries a portable mercury vapor monitor into the dome where the telescope can be viewed. Two months after coating, the surface builds up an oxide layer that protects the room from toxic vapors. Scott points out that this unlikely telescope, dwarfed by the giant dome, is the world's 17th largest. Naturally the dome for a zenith telescope need not be rotated. When asked if she ever does just to give it some exercise, she says, "yes, but it's like awakening a beast."

The lodging facilities at New Mexico Skies offer the best for visitors. Tom Polakis

The person who best exemplifies the spirit of independence required to thrive astronomically in Cloudcroft is Warren Offutt, "the dean of Cloudcroft amateur astronomy." Offutt lives on 20 acres where he operates W&B (Warren and his wife Beverly) Observatory. Active in the community, he wrote Cloudcroft's local lighting ordinance. Offutt's attention to detail and emphasis on results epitomizes everything that is right about Cloudcroft astronomers. Bruce Gillespie points out that Offutt's work is indistinguishable from that of the pros. In his ten years in Cloudcroft, he has been an abundant contributor to professional astronomy. He was recognized by the International Astronomical Union with the naming of minor planet 7139 Offutt.

Armed with a private 24-inch Ritchey-Chrétien telescope, he is taking on such challenges as trans-Neptunian and Vulcan asteroids. A retired chief technical officer for Eaton Corporation, Offutt's interest is in measurement, not pretty pictures. And as a self-proclaimed amateur, he does this professional work by allocating his own time. Before diving into his work with such vigor, he told Beverly that "this is the savings of a lifetime, so we'd better do it right." Considering their enviable living situation in the New Mexico mountains, that is quite an understatement.

As I descended the mountain road from Cloudcroft, I realized that the mountaintop astronomical community holds the future of amateur astronomy. A large population of astronomers certainly provides the power in numbers required to influence lighting ordinances and excessive growth in a community. The camaraderie of living among other astronomers can only benefit both the science and enjoyment that comes out of it. If you're looking for a move from your light-polluted city, Cloudcroft would love to have you. ■

Tom Polakis is a regular contributor.

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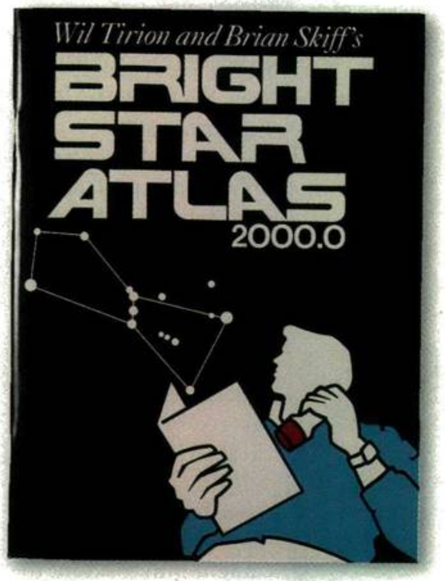
These 8x folding-roof-prism binoculars come with an objective lens diameter of 22mm; field-of-view is 400 feet (122 meters) at 1,000 yards (914 meters). The camera's aperture is fixed at f/5.6 and its optimum range is 49 feet (~15 meters) to infinity. The unit runs on three 1.5-volt (AAA) alkaline batteries.

Estimated price: $100. Meade Instruments Corporation, 6001 Oak Canyon, Irvine, CA 92618; (949) 451–1450; fax: (949) 451–1460; www.meade.com.



Bright Star Atlas 2000.0, 2nd Edition

Wil Tirion and Brian Skiff, 32 pages, Willmann-Bell, Richmond, Virginia, 2001; ISBN 0-943396-27-1; paperback, $9.95.

It is difficult to imagine a better bargain in astronomy than *Bright Star Atlas 2000.0*. For a mere ten bucks, hobbyists get a complete sky atlas containing data for more than 600 plotted objects — and it fits into a cramped accessory case. Whether you're a beginner working through the Messier catalog or a seasoned veteran, *Bright Star Atlas 2000.0* is an invaluable observing accessory.

The *Atlas* opens with six index-finder charts that guide the user to the main charts. Two pages of eloquent text — describing featured stars and deep-sky objects — follow the finder charts and lead to the main body of the work: a set of 10 small-scale charts on one page with data for interesting objects listed on the facing page. Two pairs of charts cover the celestial poles, while the remaining six provide 100° of declination range centered on the equator. For example, Chart 7 encompasses the Milky Way from Cygnus all the way to Scorpius.

True to its name, only bright stars are plotted, down to magnitude 6.5, resulting in a good match with the naked-eye view of the sky from a dark observing site. Brian Skiff selected and plotted 357 bright deep-sky objects. The scale he uses is plenty large to find the bright objects without being intimidating. Wil Tirion's usual high standards carry through with easily legible labels and symbols. Clusters and nebulae appear with representative sizes, and galaxies are shown in their correct position angles.

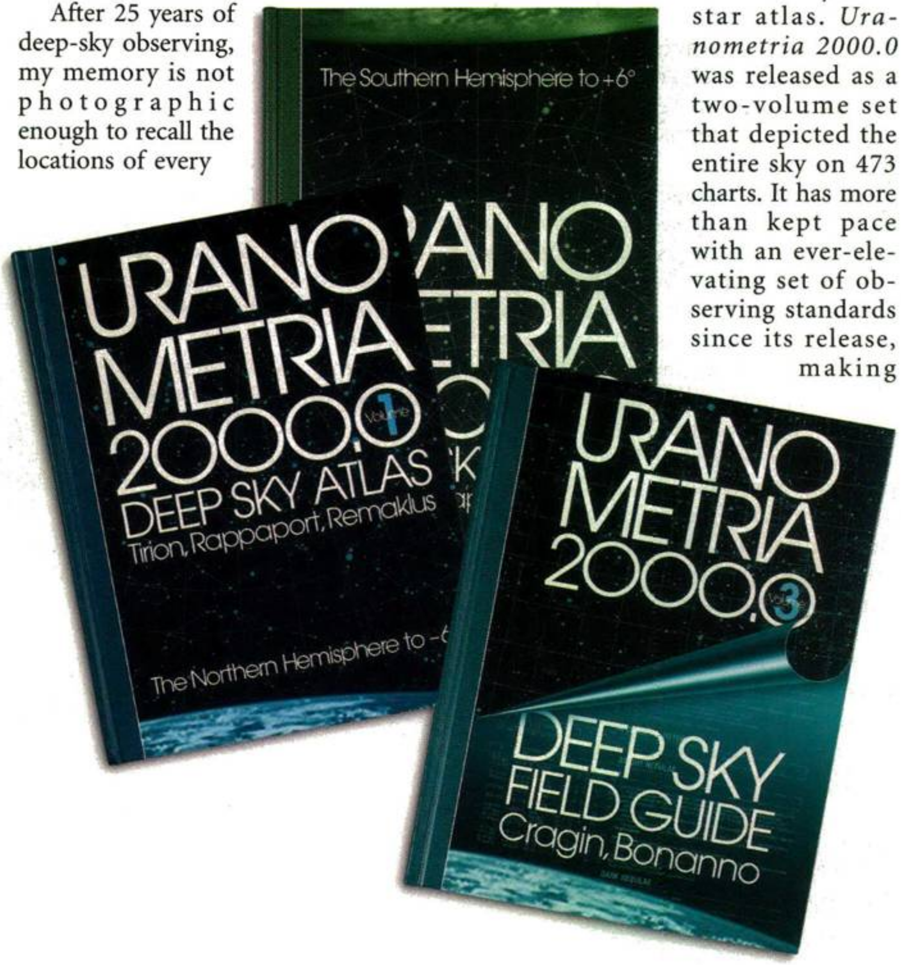
Most of the upgrading to the second edition of *Bright Star Atlas 2000.0* is in the form of subtle changes to an already near-perfect product. The Milky Way is now represented as light blue, making the associated fields more visible when viewed under a red flashlight. Charts appear less cluttered thanks to improvements in type from the first edition. Data for the nearly 9,000 stars are now taken from the European Space Agency's *Hipparcos and Tycho Catalog*. New charts of expanded scale have been added for the regions surrounding the Pleiades and Orion Nebula.

After 25 years of deep-sky observing, my memory is not photographic enough to recall the locations of every interesting object in the sky. For that reason, I find *Bright Star Atlas 2000.0* as indispensable as a red flashlight whenever I observe. It should also be equally essential for the beginning observer. Simply put, there's no better observing accessory available to amateur astronomers for such little expense. — *Tom Polakis. Tom's "Celestial Portraits" appear frequently in* Astronomy.

Uranometria 2000.0, Deep Sky Atlas and Field Guide, 2nd Edition

Willmann-Bell, Richmond, Virginia, 2001; *Vol. 1: The Northern Hemisphere to –6°* (ISBN 0-943396-71-9); and *Vol. 2: The Southern Hemisphere to +6°* (ISBN 0-943396-72-7); Wil Tirion, Barry Rappaport, and Perry Remaklus; hardcover, $49.95 each; *Vol. 3: Deep Sky Field Guide* (ISBN 0-943396-73-5); Murray Cragin and Emil Bonano; hardcover, $59.95.

In 1987, deep-sky observing was given a boost with the advent of a revolutionary new star atlas. *Uranometria 2000.0* was released as a two-volume set that depicted the entire sky on 473 charts. It has more than kept pace with an ever-elevating set of observing standards since its release, making



it evident that the reworked second edition of *Uranometria 2000.0* has raised the bar again to become the atlas to which others will be compared.

Like its predecessor, the second edition plots the sky at a generous scale of 1.85cm per degree of declination. *Volumes 1* and *2* represent the Northern and Southern Hemispheres with 6°of overlap. Although they are sold separately, there's hardly a habitable place on the planet in which an observer wouldn't need both volumes.

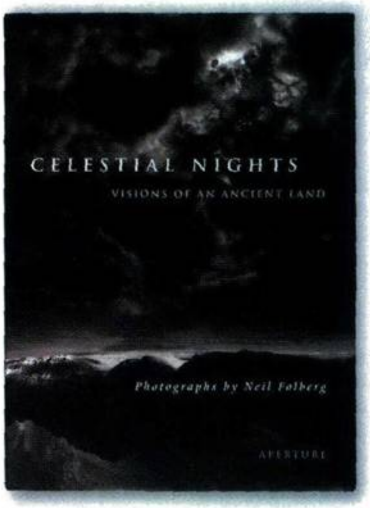
Confining a large-scale atlas to convenient 9" by 12" pages is a challenge that is handled by representing the sky in 17 strips of declination. With small constellations such as Lyra spanning some six inches of chart space, one can imagine that traversing the atlas pages is a learned skill. And it is in the area of chart navigation where the second edition makes its greatest strides. Up front, small- and medium-scale charts make homing in on the large-scale chart a simple task in the field. The large-scale pages are tabbed by declination, and plotted constellations are named in the corners. The organization of these charts is a major, favorable departure from the first edition's rather clumsy arrangement by right ascension. Two contiguous pages now comprise a single chart 18° wide.

In addition to eased navigation, the *Second Edition* makes many improvements over the prototype. Sky coverage is deepened considerably. For those keeping score, this edition plots 280,035 stars (to magnitude 9.75) as well as 25,895 galaxies, 1,617 open clusters, and 1,144 planetary nebulae, representing several lifetimes' worth of observing projects.

Star brightnesses are now represented using a continuous scale of dot size. Galaxies are shown in their correct position angles. In crowded or interesting telescopic fields, 26 charts of an even larger scale at the back of each volume help sort things out. Transparent coordinate and finder overlays are included in *Volume 2.*

Of course, none of those charts are any good if users don't understand what they're viewing. Enter *Volume 3*, the remarkable *Deep Sky Field Guide.* Data for every object plotted in *Volumes 1* and *2* is arranged by chart number. The coordinates, magnitudes, sizes, and types have been rigorously checked by a team of people who actually enjoy such labor. Catalog errors may turn up, but *Volume 3* will remain the most accurate compendium of written astronomical object data for many years to come.

What puts the catalog data above the others, though, is the column titled "Notes." Murray Cragin has examined digitized sky survey images for more than 20,000 objects, noting their structure and the location of nearby stars and fainter galaxies. At the eyepiece, these notes eliminate any doubts of identification, and should serve to reduce the number of false "discoveries" of comets and supernovae.



The three volumes are a joy to use in the field. It's fun to lay the atlas open to a part of the sky that is on the meridian and surf through the plotted objects. With *Deep Sky Field Guide* nearby, one can anticipate if there's a realistic chance of seeing an object and make comparisons between the catalog data and eyepiece impression. The chart magnitude limit conveniently matches that of a finderscope at a dark site.

I found myself viewing very faint objects with a 10-inch telescope, picking off galaxies in a group whose magnitudes approached 14. However, I found one major irritation with the arrangement of objects. Within an object class, objects are arranged by catalog designation. For example, the list of "MCG" galaxies alphabetically follows those in the IC and precede those in the NGC. Cragin presented good arguments for this approach, but when navigating through complex fields, I would have preferred them to be ordered strictly by R.A.

It's hard to find much to complain about with the second edition of *Uranometria 2000.0.* For less than the price of a premium eyepiece, the authors have created the definitive atlas and catalog combination that will keep observers busy for many years. — *T. P.*

Celestial Nights: Visions of an Ancient Land

Photographs by Neil Folberg; introduction by Timothy Ferris; Aperture Foundation, New York, 2001; ISBN 0-89381-945-X; hardcover, $40.

Neil Folberg is a widely known Israeli photographer who specializes in moody, almost spiritual landscape images. He fell in love, however, with the ways his favorite, ancient targets in Israel and the Sinai Desert look at night — particularly under clear, star-laden skies. Folberg turned to astrophotography to help him capture his vision. He sought out two fine astrophotographers who graciously taught him to shoot the glorious night skies of the desert. What makes these black-and-white images — some of which appeared in *Astronomy* in March 2000 — so unique is that they are night shots with carefully lit earthly foregrounds.

At times, Folberg captures the night scene he likes in a straightforward manner. But what he often does is marry an image of the sky with one of Earth. Sky phenomena imaged from an observatory balcony are melded with photos of nocturnal shots of architectural and natural objects captured by using special lighting. Combining images enhances the effect of Folberg's imagination; he takes us along for the ride by creating the photo he feels — which in turn elicits a strong emotional response for his viewers as well.

In the introduction to *Celestial Nights*, Timothy Ferris addresses concerns about other photographers' past efforts to combine separate images of the night sky with images of night landscape. "Some are visually striking, others technically impressive, but few look real," he writes. In comparison, he says of Neil Folberg's photos: "These

(continued on page 84)

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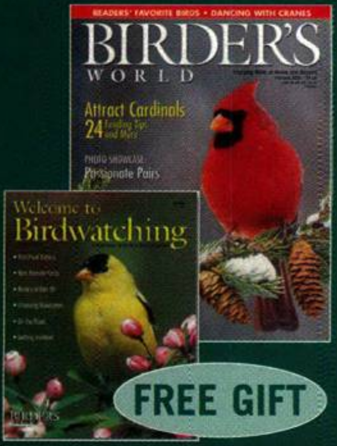
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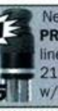

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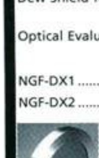

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As Written Up In Sky & Telescope June 2000

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(continued from page 80)

images actually do evoke, with striking force and authenticity, the experience of being out at night under the stars."

Ferris begins his introduction to the book with a quote from Robert Henri in *The Art Spirit*: "Art and science are so closely akin that they might very well be lumped together. They are certainly necessary to each other, and the delights of either pursuit should satisfy any man." And rightly so, Folberg tries to capture the small, still point where art and science mingle. The truth of such scenes often alludes talented photographers.

Does Folberg succeed? The genius of these images is not in the revelation of any new truth, but in the expression of unsolvable equations. We are shown both realms of the visible universe, Earth and sky. To use Folberg's own words, he makes images that "meet at the edge of the human cosmos." This wonderful and mystical collection of images makes you ponder: How can night images have so much detail and yet engender so much mystery?

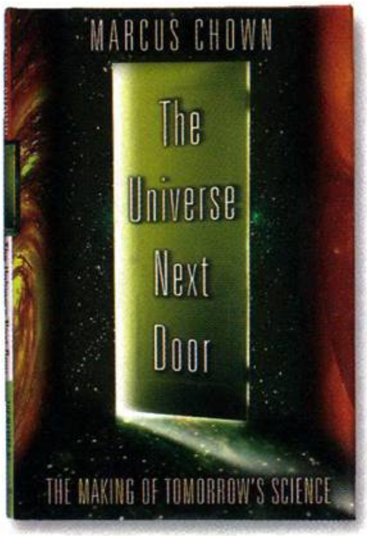
The images are as much a part of imagination as they are of reality. As Folberg says, "It is hard to say how much of my view is sight and how much is imagination." We can enjoy his vision of a stark landscape and the familiarity of the skies through these images. If all we can say about an artist is that he showed us the way he sees, then that artist has accomplished his purpose. Neil Folberg has shown us his vision, and it is nearly mystical. — *Milwaukee-based photographer Peter Sutter has published images in several national magazines. His one-man photo shows have appeared in Washington D.C., Miami Beach, Florida, and New York City.*

The Universe Next Door: The Making of Tomorrow's Science

Marcus Chown, 191 pages, Oxford University Press, New York, 2002; ISBN 0-19-514382-5, hardcover, $26.

Let your thoughts run free. Imagine what might be, then ask yourself why not? Filter out what you consider pure speculation and ponder the rest. That's the best way to introduce Marcus Chown's new book, *The Universe Next Door: The Making of Tomorrow's Science.*

Chown, an English astrophysicist trained at Cal Tech in Pasadena, is also the cosmology consultant for *New Scientist*, the respected British weekly science magazine. From his experience in that role, he writes: "I often come across ideas that blow my mind, that leave my head spinning with their far-reaching ramifications." In *The Universe Next Door*, Chown pursues those intriguing notions by interviewing a collection of renowned scientists from around the world — many of whom express very strange thoughts based on current knowledge.



Here's a sampling of some of the questions and musings: "Is there more than one reality?" "If time can run backward, might we meet ourselves coming while we are going?" "Was the universe just waiting for us (life) to come on the scene to detect it?" "Perhaps stars and galaxies don't really exist until we see them — like the famous tree falling in the woods making no sound unless someone is there to hear it." "Do our own lives follow multiple paths, splitting in an instant with different outcomes in parallel multiverses?" "Gravity doesn't exist; it's just a warp in space-time." "Black holes the size of refrigerators weighing as much as Jupiter make up 99 percent of the mass of the entire universe." "Was our universe created in a lab by intelligent beings?" "Is distant starlight dimmed to our vision by clouds of interstellar 'bacteria' that seeded life throughout the galaxy?" "A likely place to find life elsewhere is on a lonely renegade interstellar planet with no star to orbit for warmth." "Are we all E.T.s?"

All this may sound like it came from the pen of a hungry science fiction writer, but it didn't. Chown garnered these questions from credible scientists. He explains this line of thinking in the book's foreword:

"Craziness . . . is not necessarily a ground for dismissing an idea. Nature is under no obligation whatsoever to respect our sensitivities and behave in a way that appeals to everyday common sense . . . There is evidence for all the ideas presented here."

The Universe Next Door is an enjoyable book because it lets readers spend time pondering ideas that go beyond intuitive reasoning. Likewise, Chown's word images captivate readers. For example: "On a cold, lonely moon shrouded in purple-pink fog, a sentient ocean marshals the energy resources of an entire galaxy and focuses them down onto a tiny, unsuspecting mote of matter. A hundred billion stars flicker and dim . . . Crushed by stupendous energies, the tiny mote twists and bucks, and, with a violent shudder, implodes like a nuclear explosion in reverse . . . Until suddenly, without warning — puff! — it's gone. Somewhere else, in another space, another time, a searing hot fireball explodes out of nothingness and immediately begins to expand and cool. The ultimate scientific experiment has produced the ultimate experimental result — the birth of an entirely new universe." And it may be just next door. — *Nick Nichols is the retired news media relations manager at the Idaho National Engineering and Environmental Laboratory in Idaho Falls, Idaho.*

PRODUCT INFO

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The Webweaver Picks

by Richard J. Bartlett

SUNSPOTS
INTRODUCTION HISTORY MODERN RESEARCH
ACTIVITY GLOSSARY BIBLIOGRAPHY
INTRODUCTION: Page 1 of 3
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Dark spots, some as large as 50,000 miles in diameter, move across the surface of the sun, contracting and expanding as they go. These strange and powerful phenomena are known as sunspots.

This resource will allow you to explore the nature of

June provides the perfect opportunity to reacquaint ourselves with our parent star. Don't worry about buying the correct filters for viewing the sun — instead, turn to virtual solar observing.

A good place to start is the Exploratorium, which has several different pages and mini-websites. The Sunspot site at www.exploratorium.edu/sunspots/ includes photos, RealMedia movies, and details on historical and current solar research.

If you're feeling creative, try making your own sundial. Visit www.exploratorium.edu/science_explorer/sunclock.html. This page is aimed more at children than adults.

Another great place to learn about the sun is on the Stanford Solar Center website at http://solar-center.stanford.edu/index.html. Teachers will love this website, because in addition to activities for children, it includes lesson plans, links to other websites, and pages detailing solar art and folklore. Upcoming webcasts are also listed.

Next, visit the Solar Physics website for the Science Directorate at the Marshall Space Flight Center at http://science.nasa.gov/ssl/pad/solar/. These pages describe solar structure and sunspots, as well as features such as the corona, solar wind, and solar flares using animations and diagrams. Past and future solar missions are also described.

Learn how to observe the sun safely at Peter Meadows's site, www.meadows3.demon.co.uk/. Meadows is an experienced solar observer, and his website lists detailed notes, data, and diagrams on sunspot activity. You'll also find a page of tips for solar observing and a freeware program, "Helios."

Want to know how professionals observe the sun? Find out by visiting www.sunspot.noao.edu/. But if you're planning a trip to New Mexico, stop off at the National Solar Observatory on Sacramento Peak. It's a six-hour drive from Albuquerque and close to the appropriately named village of Sunspot. Visitors are welcome between dawn and dusk and can wander around on their own or join a guided tour. Anyone not able to attend can enjoy a virtual tour at www.sunspot.noao.edu/PR/virtual_tour_2.html.

It's always good to know the times of sunrise and sunset. Our first port-of-call is the U.S. Naval Observatory at http://aa.usno.navy.mil/data/docs/RS_OneDay.html. Enter the details of your location, and it not only tells you the rising and setting times for the sun, but also data for the moon — including its phase and illumination.

Plan ahead by visiting www.sunrisesunset.com/. Click on the link to create a customized calendar and calculate the information you need for the entire month. (However, if you don't live near a major city, determine your latitude, longitude, and time zone beforehand, because there are no clues to help you on the website.) A shareware program for Windows 95/98/NT can also be downloaded as a zipped 46K file. Once installed, a sun icon appears in your taskbar. Moving your mouse over the icon gives you the times of sunrise and sunset, with twilight data and other information also available.

Space Weather Center

Information and Resources about Space Weather and Sun-Earth Connections

If you love solar observing, you might envy those who live within the Arctic Circle — at least during the summer months. As everyone knows, these are the lands of the Midnight Sun. Visit www.athropolis.com/sunfr.htm to sketch the sun's path over these chilly countries.

Predicting space-weather storms is a tricky but important aspect of solar research. As charged solar particles hit our magnetosphere, aurorae are created. But those same magnetic storms can also damage satellites, endanger space crews, interfere with power grids, and adversely affect radio and TV signals.

For the very latest news and space weather warnings, check out www.spaceweather.com/. This website should top every solar observer's bookmark list. Not only does it provide up-to-the-minute images of the sun, but it also gives the latest solar wind, flare, and sunspot information. Other astronomical events, including meteors, comets, planetary conjunctions, and Near-Earth Objects (NEOs) are also listed.

The skies don't stay dark for long in June, so the chances of seeing the Aurora Borealis are fairly slim. But if you're feeling lucky you can see which parts of the globe will likely have a nocturnal light show by visiting the Geophysical Institute at www.gi.alaska.edu/aurora_predict/worldmap4.html. While you're there, check out the link to the NOAA POES satellite page at http://sec.noaa.gov/pmap/. This site is updated continuously throughout the day and night with the very latest images showing aurorae over the poles.

June brings mixed blessings if you're an astronomer. On the one hand the days are warm and sunny, but on the other the nights are short. It may be a good time for the annual "Star-B-Q" — but instead of setting up your telescope, hop on the Internet: Here comes the sun.

Visit Richard's StarLore website at http://www.starlore.net.

Anyone can sell you a telescope.

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Hardly a day goes by that we don't get a note or E-mail message like the one reprinted on the next page, or a call that goes something like this: "Your ads are right. Dealer so and so advertises low prices – but they don't have what I want in stock, they couldn't answer *any* of my questions, and they wanted my credit card number before they'd even *talk* to me. They said if I wanted to ask questions, I should call the manufacturer . . . and then they hung up on me!"

If you want the right telescope, you need more than a camera store clerk armed with only a price list and a puzzled look when you ask questions.

What you *really* need are people who take the time to listen to what *you* need, people who answer your questions truthfully, people with years of experience using and selling telescopes who help you get the most telescope for your dollar. That's exactly the kind of people you'll find at ***astronomics***.

Unlike camera stores and shopping mall gift shops, telescopes are our specialty at ***astronomics***, not just a sideline. We're a family-owned full-line telescope dealer – not just a few toy telescopes stuck off in the corner of some no-help department store, toy store, or gift shop as an afterthought. And, unlike department store clerks, we don't work on commission, so we won't try to sell you more than you need just to pad our paychecks.

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TMB 175 175mm (7") f/8	$11{,}990^{00}$
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Astronomics offers custom-made truss tube Dobsonians hand-crafted by Pete Kron, a long-time Astronomics customer who is now a full-time member of our staff. Pete has been custom-building Dobs for over 15 years, in sizes up to a 36" f/5, and is known for his exacting quality standards. While Pete specializes in 18" through 24" apertures, custom mirror sizes and focal ratios are also available. He can also upgrade your unwieldy commercially-made Sonotube Dobsonian to an easily transportable truss tube version.

Prices start at $3500 for a custom-built 18" scope. Converting your commercially-made Sonotube Dob optics to a truss tube mount starts at $1500 for a 16" f/4.5 scope.

For more information, or to discuss specific pricing, contact Pete via e-mail care of questions@astronomics.com. You can also reach him by phone toll-free from 9 to 5 Monday through Friday at (800) 422-7876.

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The NexStar 11" got a great review. You can have your 11" in a week.

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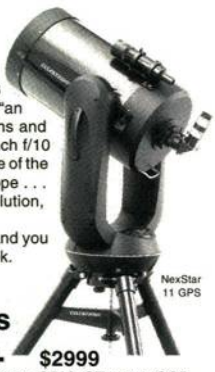
We have the NexStar 11 in stock (22 as this was written). Call us and you can be observing with yours within about a week.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The NexStar 8 GPS is a super choice for CCD, as well as visual observing.

NexStar 8 GPS $2499

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65mm x 80mm Holds most illuminated reticles, 22mm Panoptic, 12mm Nagler, etc.	$3^{99}

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NexStar
8
$1499

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6" f/8 DHQ, shown with optional eyepiece rack
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6" f/8 Discovery DHQ	**$299^{00}**, plus $49 freight
8" f/6 Discovery DHQ	**$399^{00}**, plus $49 freight
8" f/7 Discovery DHQ	**$399^{00}**, plus $49 freight
10" f/4.5 Discovery DHQ	**$599^{00}**, plus $69 freight
10" f/5.6 Discovery DHQ	**$599^{00}**, plus $69 freight

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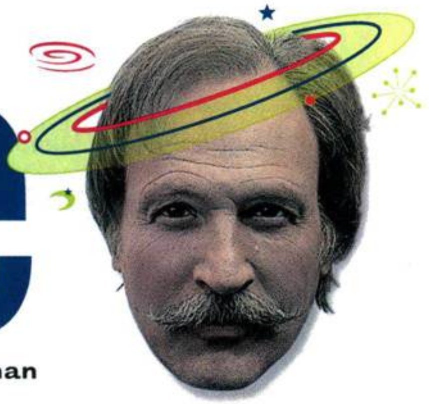
strange Universe



by Bob Berman

Wrong Time, No Bang

Astronomers generally regard the Steady State theory as a lovely idea that is as dead as the passenger pigeon. Older than science itself, the notion of an eternally existing universe is widely associated with Sir Fred Hoyle who, until his death last August, crusaded for its acceptance since the 1940s. Certainly it carries great philosophical appeal.

After all, its rival, the Big Bang (a name Hoyle himself disdainfully coined), promises only a cosmos that will either someday crush itself down to the size of a pea, or else — much more likely — blow itself apart into isolated icy islands of frozen death.

Neither sounds particularly attractive.

Tough luck, say astrophysicists. The universe will perform its drama on its own terms; our sensibilities are irrelevant. And because we trust science, most of us are pretty much resigned to the Big Bang's dreary denouement, and are consoled perhaps by the fact that humans will no longer be seated in the audience.

Yet many harbor a hopeful feeling that the same cosmos that came up with Beethoven and beagles will not utterly self-destruct. Optimists argue that any sort of permanent turn-off-the-lights nothingness seems out of character with the universe's leitmotif.

Wishful thinking? Perhaps. A lot of impressive evidence supports the Big Bang. Why else do we observe a 2.7° K background radiation, a specific ratio of hydrogen to helium to lithium, and redshifts that indicate an expanding universe? Is there any plausible escape clause without resorting to wacky stuff unworthy of science and logic?

Surprisingly — yes. And rather than being a "stretch," it's looking more and more like something not to be dismissed out of hand. It all comes about if we entertain the possibility that time gradually changes its rate of flow.

This is hardly a new notion, nor was its chief advocate any sort of crank. No less a physicist than Paul Dirac, who first predicted antimatter in 1928 and later won the Nobel Prize, argued periodically that there's no reason time should flow at a steady rate forever.

Time is strange to begin with. On many levels — and perhaps even on the most fundamental planes — it may not exist at all. Until interactions between kaons and their antiparticles showed a slight asymmetry a couple of years ago, it was hard to find any solid evidence that time really existed, though the Second Law of Thermodynamics was sometimes controversially invoked for its support. (Our minds' ability to link experiences with remembered or anticipated occurrences is not the same thing as time. Thoughts of the past or future are, after all, neuro-electrical events that occur strictly in the present moment.)

But let's not make this unnecessarily mysterious. Rather than invoke other dimensions, we can simply deal with time's everyday guise as a sort of synchronicity between events. While half of a carbon-14 sample decays, Earth performs 5,730 orbits of the sun and Saturn circles our sky 196 times. Those three events and trillions of others will continue to occur in sync. Dirac's question: What if the whole shebang gradually slows down in unison and on every level? We wouldn't notice a thing, but it would have enormous cosmological implications.

If time ran differently long ago, we could now observe a cosmic background radiation that pointed to a Big Bang that would seem to have happened 14 billion years ago. In reality, said Dirac, the universe would be infinitely old. There would not be a natal instant of creation. It would all revert to some variation of Hoyle's Steady State theory.

Variable time seems more likely now than it did a year ago. Physicists recently uncovered evidence that the universe's physical constants do indeed change. Specifically, the strength of the electromagnetic force ("Alpha") was apparently a tiny bit smaller eight billion years ago. Astrophysicists reached this conclusion after observing photons interact with distant nebulae on their way to Earth. Indeed, the value for the Planck Constant, which in turn derives its stability from the supposedly unchanging nature of three other constants, seems to have been slightly different back then. That astronomers measured this alteration to be exactly the same in many separate places gives the discovery far more credibility than if the effect derived from a single observation.

If some "constants" can change over the eons then why not time? Dirac directed particular suspicion toward the stability of the gravitational constant, finding no reason its force, among others, has to forever remain the same. In fact, if time alone has changed, then other things can seem to alter but actually be constant.

Tricky business. Even if it were happening, we would not expect to see any difference in the flow of time when we observe far off galaxies. Their images have long been traveling to us, and during that vast en route interval their incoming photons have also been caught up in the new rate of time passage. When we finally observe distant images, frames of that movie run through the projector of today's temporal pace, so that it appears no time mutations have occurred at all. How, then, can we know one way or the other about the rate of time's passage?

Evidence on Earth might reveal it, except that our measurements of the way time passed here a million years ago are not remotely precise enough to detect a minute alteration from the way it flows today. Dirac himself could offer no decisive way to determine whether or not time is stable.

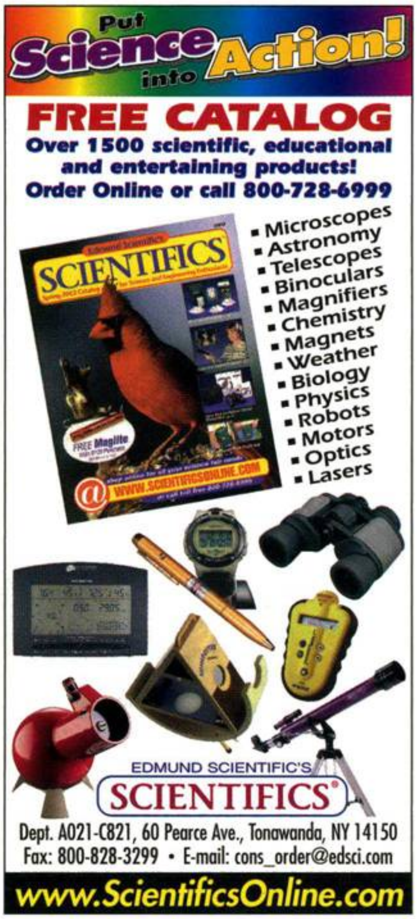
What do we do with all of this information? Armed with credible evidence that one or more of the universe's constants may not be constant, but lacking any knowledge that time could also mutate, our conclusions are limited. Still, those of us who teach science may well wonder whether we should really present the Big Bang as a done deal.

It's probably safest to tell students current evidence points strongly to a Big Bang that happened 14 billion years ago. Further, the cosmos appears to be increasing its rate of expansion and therefore seems unlikely to ever come back together into a crunch that offers rebound possibilities. This means that right now, we don't seem to be mailing our letters in an oscillating universe that eternally inflates and deflates like a balloon.

But the case is far from airtight. A little intellectual humility never hurts, especially when the prospect persists that the universe is infinitely old and never had any sort of birth at all. Our impatience notwithstanding, it's still too early to know for certain whether or not the Game is played "according to Hoyle."

Face it: We've only begun to decipher the rulebook. ■

Bob Berman's "Strange Universe" column is a monthly feature in Astronomy. *Berman also is the author of two wonderful guides for astronomers:* Secrets of the Night Sky *and* Cosmic Adventure.



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The Internet is a popular and valuable tool for amateur astronomers and astronomical organizations. Skygazers create personal pages to display astro images or observation logs. Observatories maintain websites with the latest images shot through their scopes. Clubs use the web as an outreach to bring fresh blood into the hobby.

On *Astronomy*'s website, visitors are able to find astronomical events and organizations in a searchable database of organizations and a calendar.

Astronomical organizations can maintain their own group listing that features an overview, contacts, web links, and membership information. Also, each organization is provided with a personal forum where registered members can discuss anything relating to astronomy or their group.

The Organization Guide and Calendar of Events are useful to general users as well. Not only are visitors able to find an observatory or museum in their area, but possibly a star party to plan a vacation around. And since the calendar lists upcoming sky events, amateurs can schedule a night of observing months in advance.

To find *Astronomy.com*'s Organization Guide, visit http://www.astronomy.com/Clubs/findaclub.asp; or to locate the Calendar of Events, go to http://www.astronomy.com/Calendar/Default.asp.

Alan Dyer

Locate star parties, such as the Riverside Telescope Makers Conference, on *Astronomy.com*.

MAY 24–MAY 26

Riverside Telescope Makers Conference

Y.M.C.A. Camp Oakes, California, near Big Bear City. The 33rd annual Riverside Telescope Makers Conference is organized around the themes of "Deep Sky" and "Women In Astronomy." Activities include a swap meet, workshops, lectures, horseback riding, hiking, contests, awards, and, of course, observing. Housing options are dormitory residence or camping in campground shelters. For more information, contact Bob Stephens, (909) 948–2205; 8300 Utica Avenue, Suite 105, Rancho Cucamonga, CA 91730; e-mail rstephens@foxandstephens.com; website, http://www.rtmcinc.org/about.html/.

MAY 25

Shreveport-Bossier Astronomical Society Star Party

Ralph A. Worley Observatory, Shreveport, Louisiana. For additional information, contact (318) 797–1524; e-mail clucas@softdisk.com; website, http://www.lsus.edu/nonprofit/sbas.

JUNE 2–6

American Astronomical Society 200th Meeting

University of New Mexico, Albuquerque, New Mexico. For additional information, contact Diana Alexander, diana@aas.org; website, http://www.aas.org/meetings/index.htm.

JUNE 4–11; JUNE 14–22; JUNE 28–JULY 1

University of Arizona Alumni Association Astronomy Camp for Teenagers and Educators

Mt. Lemmon and Mt. Bigelow, Tucson, Arizona. Sponsored by the University of Arizona Alumni Association and Steward Observatory. Beginner teens, June 4–11; advanced teens, June 14–22; educators, June 28–July 1. For more information, contact Don McCarthy, (520) 621–4079; 933 N. Cherry Ave., Tucson, AZ 85721; e-mail dmcarthy@as.arizona.edu; website, http://ethel.as.arizona.edu/astrocamp/information.html.

JUNE 5–9

Laurel Highlands Star Cruise

Pine Hill Campground, near Hazelton, West Virginia. Join fellow astronomers from Pennsylvania, surrounding states, and Canada for a variety of astronomical activities along with beautiful dark skies. For more information, e-mail jwholtz@aol.com; website, http://www.lhstarcruise.org/.

JUNE 7–9

Jersey StarQuest 2002

Hope Conference and Renewal Center, Hope, New Jersey. Sponsored by the Amateur Astronomers Association of Princeton, Inc., StarQuest will feature dark skies, astrophotography workshops, dealers, swap tables, and a flea market. Registration deadline is May 22, 2002. For more information, contact Anthony Monticello, Registration Chairperson, 270 Fieldboro Drive, Lawrenceville, NJ 08648; e-mail anthony_monitcello@hotmail.com.

JUNE 7–9

Mason-Dixon Star Party

Spring Valley County Park, York County, Pennsylvania. The York County Astronomical Society, in association with the York County Department of Parks and Recreation, will host the 13th annual Mason-Dixon Star Party. The keynote speaker is Phil Harrington. For more information, e-mail info@masondixonstarparty.org; website, http://www.home1.gte.net/dmdewey/mdsp.html.

JUNE 7–9

Wisconsin Observer's Weekend

Hartman Creek State Park, west of Waupaca, Wisconsin. Sponsored by the Northeast Wisconsin Stargazers. For more information, contact Ty Westbrook at (920) 733–7264 or e-mail Ellwest4@aol.com; website, www.newstar.org.

JUNE 8–15

Grand Canyon Star Party

North and south rims of Grand Canyon National Park, Arizona. The Tucson Amateur Astronomy Association and the National Park Service jointly sponsor this 12th star party at the Grand Canyon National Park. For more information, contact Dean Ketelsen, 1122 East Greenlee Pl., Tucson, AZ 85719; (520) 293–2855; e-mail ketelsen@as.arizona.edu; website, http://www.tucsonastronomy.org.

JUNE 14–JUNE 15

32nd Apollo Rendezvous

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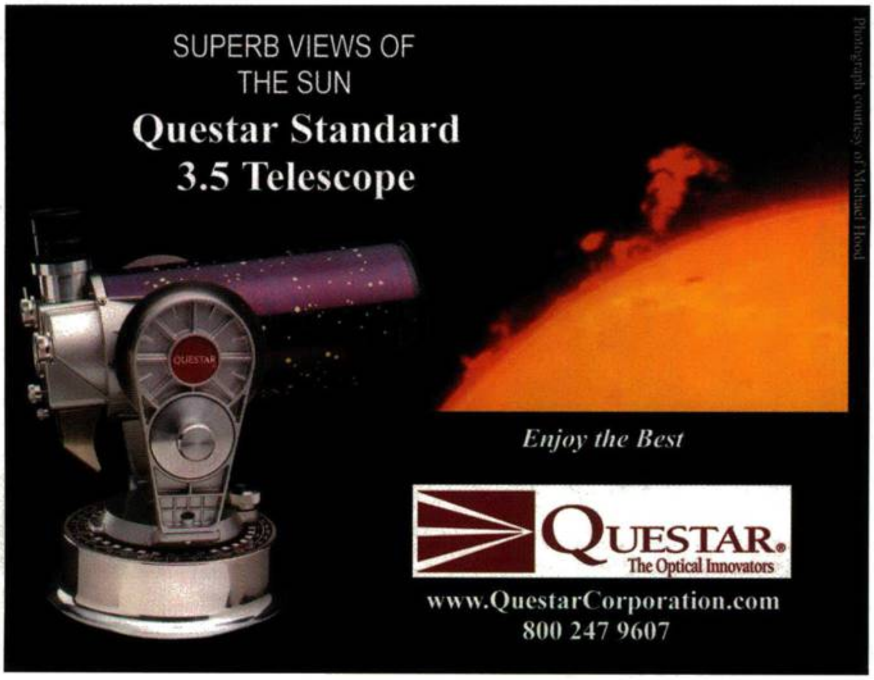

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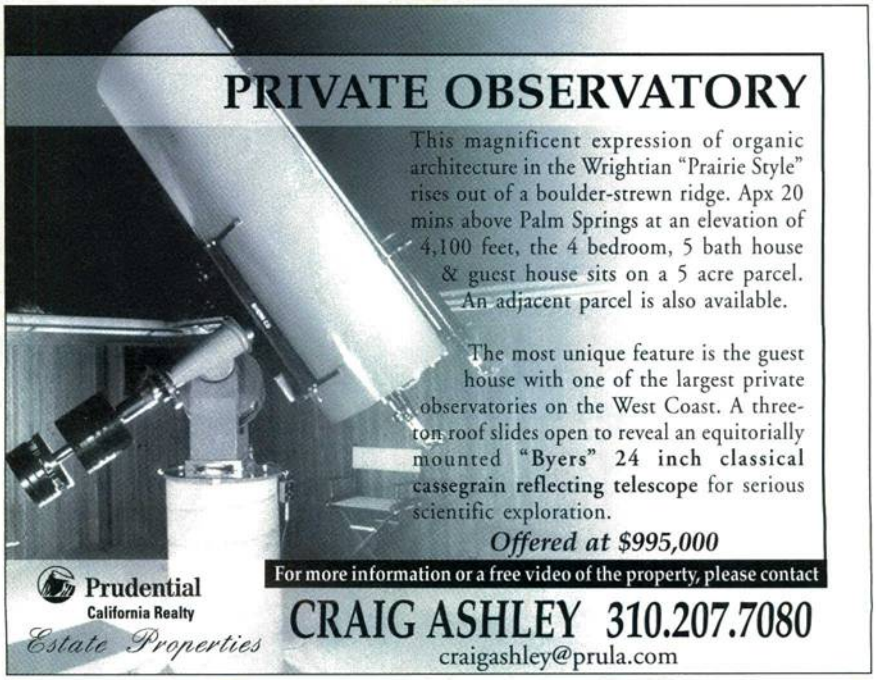

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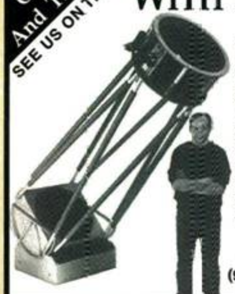

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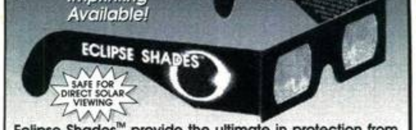

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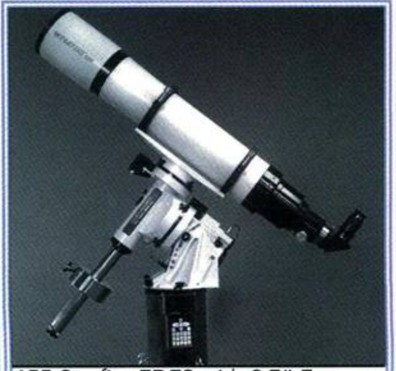

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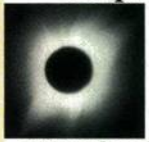

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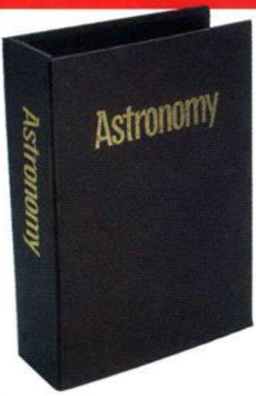

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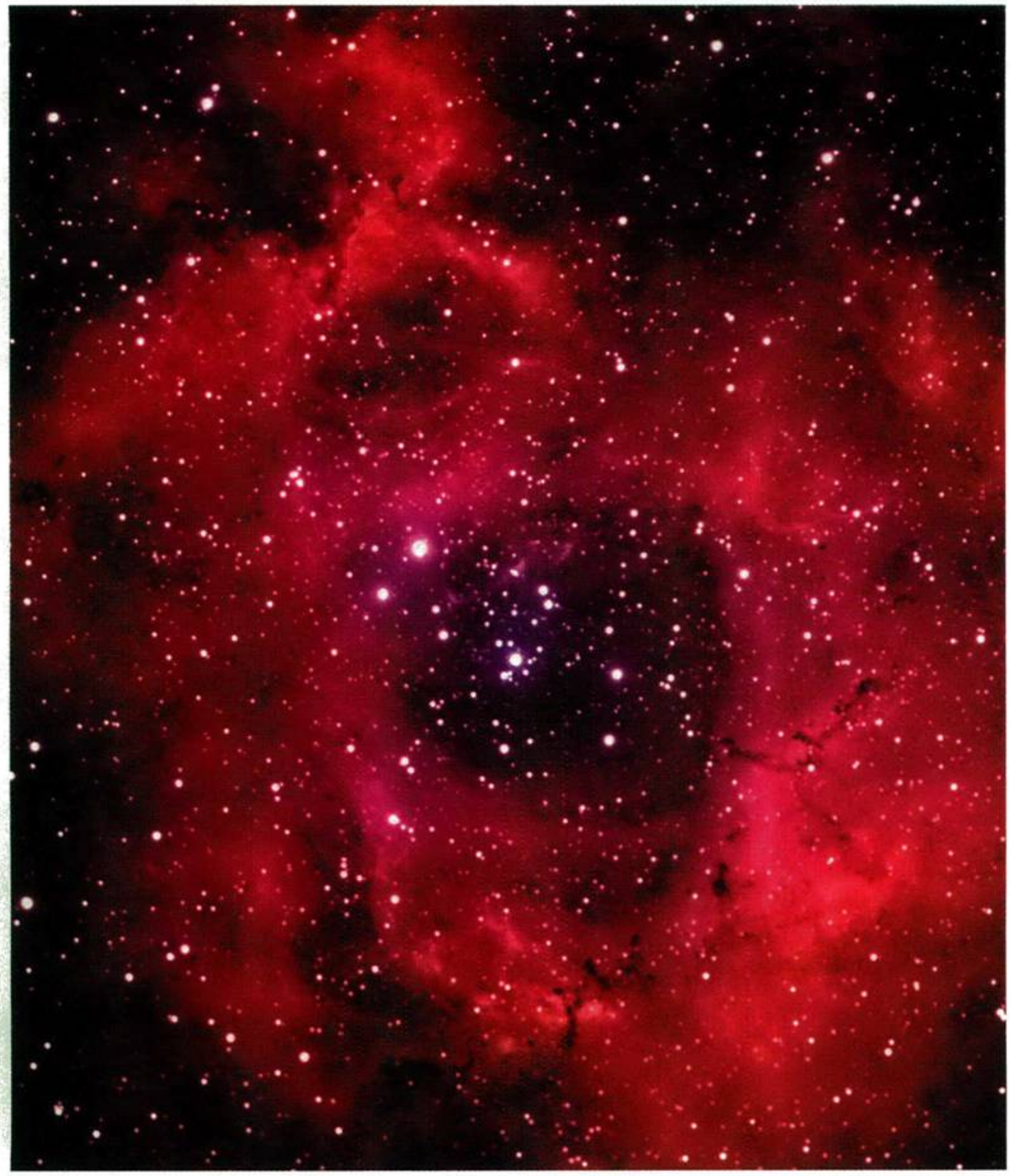
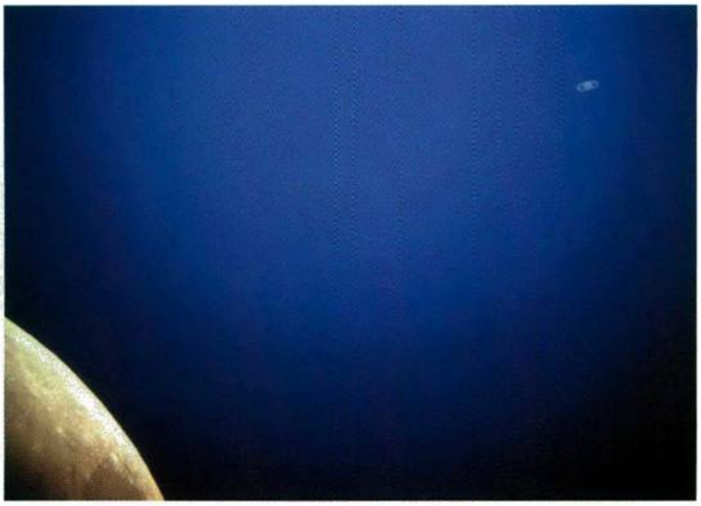
ASTRO LESSONS

Learning the Hard Way

On an unusually warm, clear Friday evening in late November, I took my 6-inch Dobsonian telescope out on my deck to photograph the moon. In the past, I had achieved limited success taking astrophotos with an old manual camera, but I had never kept track of my efforts. But on this night, I was determined to record the specifics for each shot I took. As I was focusing the scope on the moon, I noticed an unusual object right next to it. As I looked closer, I realized the object was Saturn. Suddenly, I was poised to capture a photo of the moon occulting Saturn. I took two rolls of pictures at a furious rate, using the eyepiece projection method and varying the exposure times. But in my excitement, I neglected to record any data. As soon as I could, I took the film to a one-hour photo lab, and breathlessly awaited the results. I was greatly disappointed to find that Saturn appeared on only one of the photos, and as nothing more than a dim smudge. As if to mock me, the January issue of *Astronomy* arrived the next day, containing an excellent amateur photo of the moon occulting Saturn.

I soon found out that I would have an opportunity to redeem myself — another occultation would occur in late December (although inconveniently, at 4 A.M.) Happily, my understanding wife presented me with a digital camera for





Rosette Nebula (NGC 2237-9)

MATHEW T. RUSSELL

(5-inch refractor at f/5, SBIG ST-10E CCD camera, composite exposure)

Daylight Occultation

PATRICK FORSTER

(6-inch reflector, Kodak DC 5000 digital camera, ⅒-second exposure taken February 20, 2002)

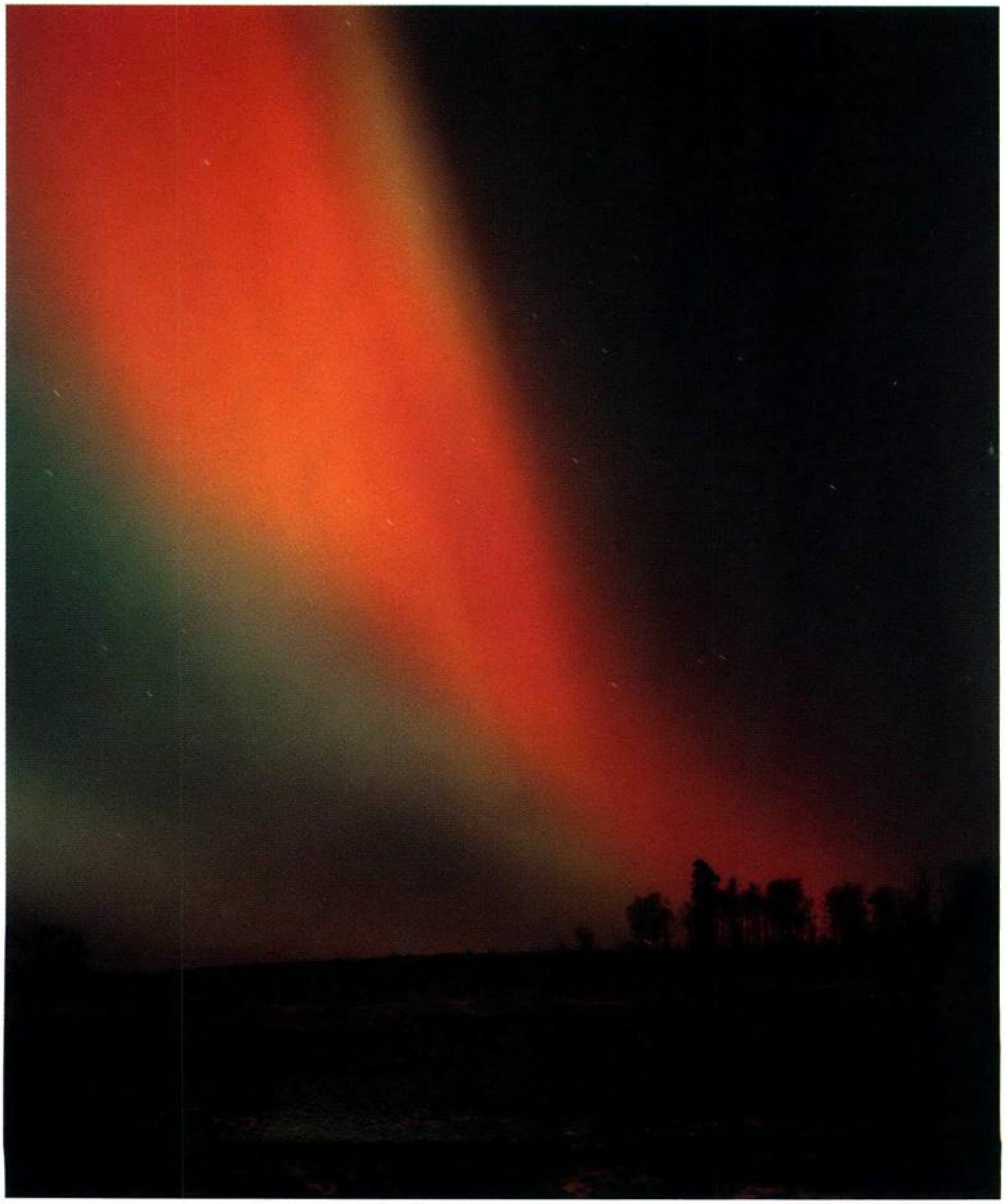
Christmas. Over the next few days, I used the camera frequently, and even captured some respectable photos of Jupiter and Saturn by simply holding the camera up to the eyepiece. So on the morning of December 28, I got up by 3:30 A.M. (which was quite an accomplishment in itself.) I took my scope outside to cool it down, and relaxed with some coffee as I waited. I figured I had plenty of time to spare. I then began to prepare my camera for its manual mode. But to my horror, it wouldn't work. After several moments of panic, I recalled reading that digital cameras drain batteries very quickly. And as much as I had used the camera in the past few days, that surely was the problem. With only a few minutes to go, I needed batteries fast. Fighting off the panic, I quickly borrowed batteries from my youngest daughter's new toys and put them in the camera. I then rushed to the scope, only to find that Saturn had already disappeared behind the moon. I resolved to get my picture as Saturn emerged from the other side of the moon. But by that time, the moon was low in the sky and approaching the top of a line of trees. I tried hoisting the scope on a table, but the table wobbled like a top. Plus, it was too late; the moon was completely hidden by the trees, with Saturn still behind it. I never got the picture, but I learned a valuable lesson that I'll remember — always check your equipment before the big event.

Michael Rutledge is an amateur astronomer in Chantilly, Virginia.

Milky Way over Arizona

FRANK ZULLO

(50mm lens at f/2, Kodak EES 800 film, composite exposure)



Canadian Aurora

CLAYTON FREESON

(36mm lens at f/2.8, Fuji 100 film, 40-second exposure)

Moon Occulting Saturn

JUSTIN LINICK

(16-inch SCT at f/10, SBIG ST8E CCD camera, composite of 40 exposures taken February 20, 2002)

Jupiter

DAVID HANON

(7-inch refractor, composite of 46 video frames taken on February 11, 2002)

The Big Dipper

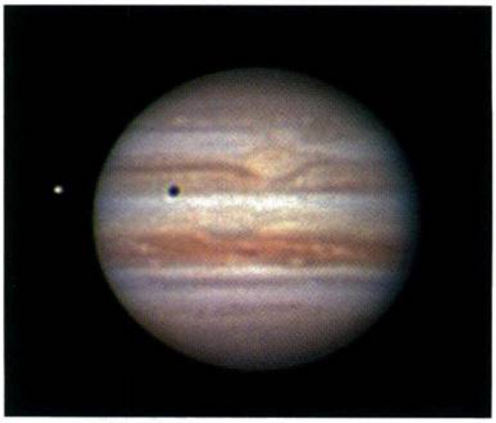
RANDALL WEHLER

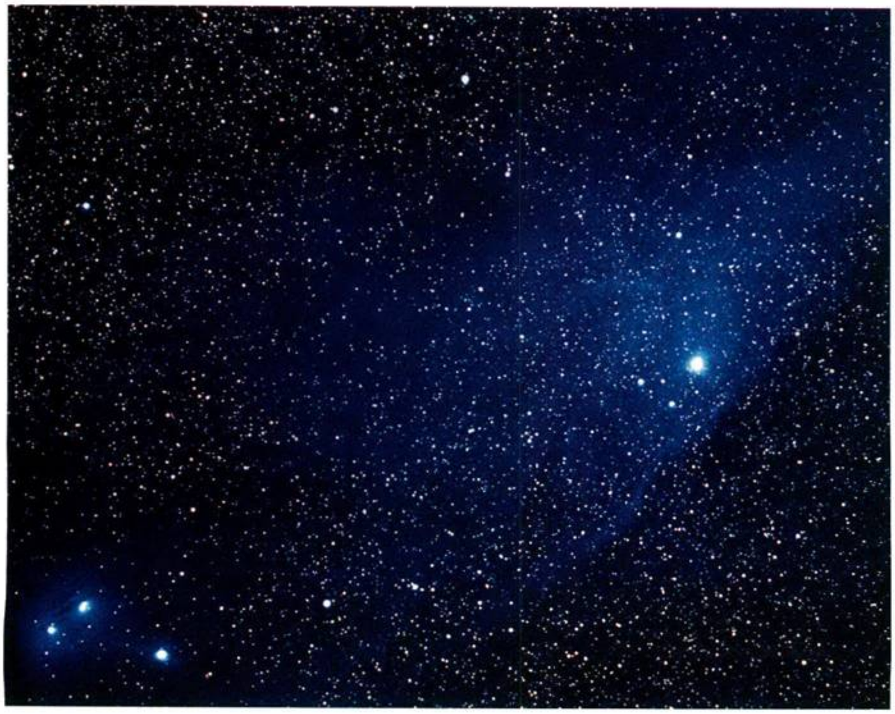
(50mm lens at f/1.4, Kodak Elitechrome 400 film, 35-second exposure)

Reflection Nebulae IC 4592 and IC 4601

GEORGE GREANEY

(6-inch refractor at f/7, hypered Kodak 400 film, composite of three 45-minute exposures)





Saturn

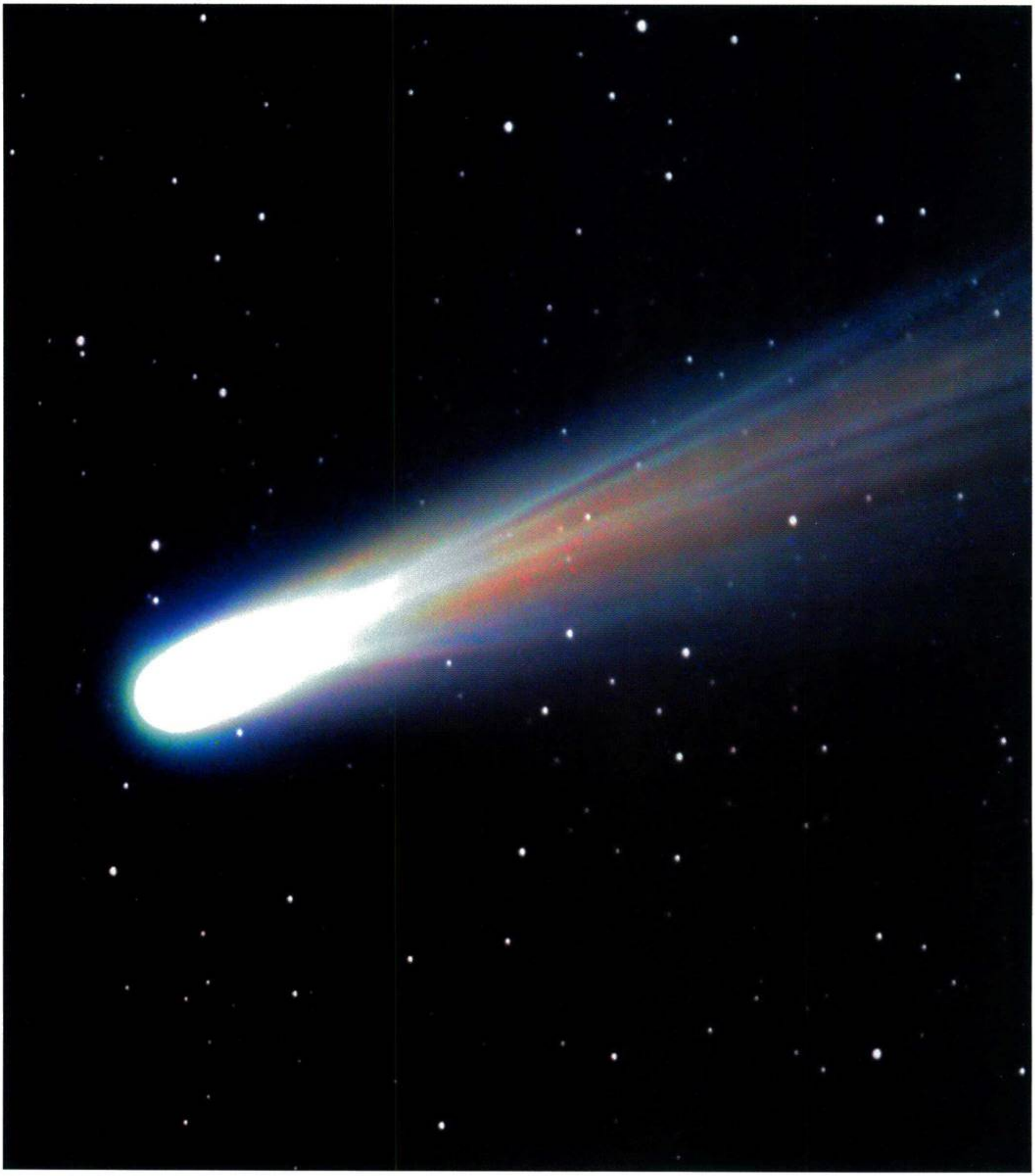
DAVID HANON

(7-inch refractor, composite of 46 video frames taken on February 12, 2002)

Star Trails with Aurora

JOHN NEMY

(28mm lens at f/4.5, Kodak Elitechrome 200 film, 180-minute exposure taken from Manitoulin Island, Ontario, Canada)



Comet Ikeya-Zhang (C/2002 C1)

JACK NEWTON

(7-inch apochromatic refractor at f/9, Finger Lakes Dream Machine CCD camera, composite image)

This beautiful image was taken on March 9, 2002, from Chiefland, Florida.

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